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COTTON GROWING IN THE NEW REGIONS OF THE USSR.

FIRST COLLECTION

INSTITUE FOR SCIENTIFIC RESEARCH ON COTTON GROWING, DEPARTMENT OF AGRICULTURAL TECHNOLOGY IN THE NEW REGIONS OF THE USSR.

Gosizdat for Kolkhoz and Sovkhoz Publications. Moscow and Leningrad. 1934.

RESULTS AND PROSPECTS OF COTTON GROWING IN THE NEW REGIONS

T. I. KVITKO

RESULTS OF THE DEVELOPMENT OF COTTON GROWING IN THE NEW REGIONS.

Attempts to introduce the cotton plant into the new regions began at an early date. In the 17th Century measures were taken to "cultivate cotton" in Astrakhanskiy Kray. The first experimental sowings of cotton in Terek, North Caucasian Kray, and in Kerch, in the Crimea, are noted at the end of the 19th Century. During the second decade of the 19th century the first preliminary studies of the possibility of cotton growing in the South Ukraine commenced. In the 1880's cotton was planted by separate farms in villages located on the plains of Dagestan. From 1888, planting of cotton at different points in the new regions continued intermittently up to the outbreak of the imperialistic war. But the question as to the possibility of large-scale cotton growing in the new regions remained undecided until the October Revolution. The reason for this lay in the social and economic structure of Czarist Russia; price regulated the development of the national economy. It was by virtue of price which caused each private entrepreneur to invest his funds, using as his starting point the market demand in whatever branch afforded him the possibility of obtaining a

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large profit in a short time. Market conditions in Czarist Russia were such that cotton grown in the new regions could not compete either with cotton from Central Asia nor with that from America, produced under conditions of intensified exploitation of labor in both the latter cases - of the Dekhans in Russia and of the Negroes in America. This is why all attempts to introduce cotton growing into the new regions during the pre-revolutionary period met with failure.

Only under the conditions of the planned Soviet economy did large-scale commercial cotton growing become possible in the new regions. In its historic resolution of July 18, 1929 "On the Development of Cotton Growing", the TsK of the VKP(b) pointed out the need for "taking more decisive measures to develop cotton growing in the new areas (Dagestan and North Caucasus) and to expand the experiments in cotton growing (Ukraine, Crimea, Astrakhan) by widespread distribution of the proper varieties of early maturing seed, by granting insurance against crop failure and conferring other advantages, so as to bring the total acreage under cotton in the new regions up to 200,000 hectares by the close of the Five Year Plan."

As a result of the accomplishment of the Party resolution, the new regions scored a major victory on the cotton front, expressed in the clearest way by the very significant increase of the acreage under cotton.

The Party's directive to expand cotton acreage in the new areas to 200,000 hectares by the close of the first Five Year Plan was thus over-fulfilled by more than 50 percent, as may be seen from the table.

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DYNAMICS OF ACREAGE UNDER COTTON IN THE NEW REGIONS BY SOCIAL COMPOSITION OF THE PRODUCERS. 1928 - 1932

(in thousands of hectares)

(Figures taken from the book The Socialist Reconstruction of Cotton Growing, 1934)

Regions	1928				1929				1930				1931				1932			
	Total	Sovkhoz	Kolkhoz	Individuals	Total	Sovkhoz	Kolkhoz	Individuals	Total	Sovkhoz	Kolkhoz	Individuals	Total	Sovkhoz	Kolkhoz	Individuals	Total	Sovkhoz	Kolkhoz	Individuals
Dagestan	1.1	--	--	1.1	3.1	--	0.9	2.2	13.4	0.5	2.9	10.0	21.1	4.1	9.0	8.0	20.9	3.5	11.5	5.9
North Caucasus	0.6	--	--	0.6	6	--	1.5	4.5	69.2	4.5	58.2	6.5	160.5	21.5	132.0	7.0	140.5	23.1	105.4	12.0
Crimea	--	--	--	--	0.1	--	--	0.1	4.7	0.1	2.7	1.9	27.3	3.0	23.0	1.3	27.3	3.7	22.7	0.9
the former Lower Volga Rayon	0.6	--	--	0.6	1.5	--	0.6	0.9	2.2	--	1.8	0.4	0.6	0.1	0.5	--	2.5	--	2.5	--
Total for the New Regions of the RSFSR	2.3	--	--	2.3	10.7	--	3.0	7.7	89.5	5.1	65.6	18.8	209.5	28.7	164.5	16.3	191.2	30.3	142.1	18.8
Ukraine	--	--	--	--	--	--	--	--	15.0	--	12.6	2.4	144.5	5.4	124.5	14.6	143.2	10.2	128.2	4.8
Total for the New Regions	2.3	--	--	2.3	10.7	--	3.0	7.7	140.5	5.1	78.2	21.2	354.0	34.0	389.0	30.9	334.4	40.5	270.3	23.6

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The movement of cotton acreage in the socialized sector shows that this sector has played a dominating role here since the very beginning of extensive commercial cotton growing in the new areas. In 1930 it had 72.3 percent of all such acreage in the new regions, 93 percent in 1931 and 89.3 percent in 1932. The importance of this fact for the development of cotton growing in the new areas was decisive. The sovkhozes, as the leading force in agriculture, were the pioneers in cotton growing on great tracts of land, and played a tremendous role in its development in the new regions. The population became convinced by the example of the cotton sovkhozes that cotton growing was possible and expedient, and took the first steps on the path of widespread commercial planting of cotton.

The following table shows the total harvest of raw cotton in the separate krays and republics.

TOTAL PRODUCTION OF LINT COTTON, 1928-1932

(in tons)

RAYON	1928	1929	1930	1931	1932
Dagestan	55	210	1467	3891	5080
North Caucasus	34	1187	5819	29577	25638
Crimea	--	9	275	5402	3331
Former Lower Volga	24	113	262	245	441
TOTAL FOR NEW REGIONS OF RSFSR	113	1519	7823	39115	33440
Ukraine	--	--	1323	36536	25181
TOTAL FOR THE NEW REGIONS	113	1519	9146	75651	58621

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The new cotton regions thus yielded 145,050 tons of raw cotton to the country during the First Five Year Plan, which made a practical contribution to the fulfilment of the directives of the Party and the government on the liberation of the textile industry of the USSR from dependence on foreign countries.

It must be noted that the technological quality of cotton from the new regions is not worse than that of the old cotton regions.

"The strength of fabrics woven of cotton fiber from the new areas does not compare unfavorably with that of the usual factory assortment produced from Central Asian cotton, and sometimes excels it; in this respect variety Number 1306 showed a higher quality than the other selected varieties." (From the report of the Cotton Sector of NITI for 1931.)

This quality refers to the cotton of the 1931 crop, when the Ukraine bolshevistically organized the cotton campaign, as a result of which the average yield in that year was about 3 tsentner per hectare from the total harvested acreage of 144,500 hectares. In 1932 the textile industry commenced to note a certain deterioration in the thecnological qualities of the raw cotton from the new regions, which may be attributed to poorer tillage of the cotton fields here, which considerably increased the proportion in the total crop of lint picked after the frost, and exerted an unfavorable influence on its quality.

Data on productivity per unit area is also of interest in any appraisal of cotton growing in the new regions. The yield of lint per hectare from 1928 to 1932 is given in the following table.

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YIELD OF LINT PER HECTARE, 1929-1932
(in Tsentner)

AREA	YEARS 1928	1929	1930	1931	1932
Dagestan	0.5	0.6	1.17	1.52	2.4
North Caucasus	0.5	2.0	0.82	1.77	1.8
Former Lower Volga	0.3	0.7	0.8	3.13	1.35
Crimea	--	1.0	0.75	1.57	0.86
Ukraine	--	--	0.66	2.92	1.7

The table shows a somewhat varied picture of the average productivity of cotton in the different krays and republics. In Crimea, Lower Volga and Ukraine, the productivity rises in some years and falls in others, while for the remaining areas it rises uninterruptedly throughout the entire period, reaching in 1932, 2.4 tsentner per hectare for Dagestan and 1.8 tsentner per hectare for the North Caucasus. These yields, however, still appear low in comparison to the possible productivity of these areas.

The cause of the low average productivity of cotton may be found not in unfavorable natural conditions in the new areas, but in failure to fulfil the basic requirements of cultural practice for cotton growing. This is emphasized by the data on the progress of fulfilment of cultural operations for this crop in 1931 and 1932. Of the extremely important breaches of sound technical procedure, which repeat themselves year after year in the new regions the following must be pointed out: the stubble from the preceding crops of wheat, corn, etc. is not disked into the soil before plowing, very little plowing is done on the seedbed, preliminary tillage of the ground is very inadequate (light plowing and insufficient harrowing), and the sowing is unduly delayed.

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Cultivation, which is of decisive importance in securing high yields, is carried out only partially and broken off at the third stage.

FULFILMENT OF CULTIVATION OPERATIONS

(in percent)

Stage of Cultivation	Two Year Average for 1931-1932	1931	1932
First Stage (to June 10)	51	64	42
Second Stage (to May 25)	15	31	10
Third Stage (to July 15)	0	0	0
Percent of acreage with crop failure.	--	22	27

/Translator's Note; the dates for the first and second stages are either transposed in the text, or, what is more probable, the second stage should be June 25 instead of May 25./

It is entirely clear that even without considering the other serious breaches of sound technical procedure, a normal yield cannot be expected if the three compulsory cultivations are carried out in this fashion.

All these circumstances, taken together, are responsible for the high percentage of cotton acreage with crop failure (22 percent in 1931 and 27 percent in 1932), the diminished productivity and the deterioration in the cotton fiber as a result of the increased proportion of bolls picked after the frost.

What is the reason for these omissions in the field of cotton growing in the new regions?

We must note in the first place the embittered resistance of

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the class enemy to the development of cotton growing in the new areas. Class war, centered around cotton, appears in the most varied forms in the new regions. During the initial period of cotton growing in the new regions, the kulaks, in their agitation, took advantage of the low cotton productivity resulting from the fact that the population had not yet sufficiently mastered the technique of producing this new crop, and used this to show the unsuitability of cotton for growing by collectives and individual farmers. From this they frequently proceeded to more energetic methods of fighting the growing of cotton, demonstrating before the population by sowing cereal and gourd crops on the plowed fields allocated to cotton, plowing up fields planted in cotton, destroying the cotton plants during cultivation, and refusing to harvest cotton under the pretext that the last crop had failed. Beyond this, there were even cases in which the kulaks burned the harvested cotton and turned their cattle onto the cotton-fields to ruin the crop. The class enemy finally adapted his tactics to the changed situation resulting from the final victory of the kolkhoz system over the old system and from the fact that the collective farmers came to realize that cotton was a valuable crop for the country and a very profitable one for themselves. These changed tactics of the kulaks consisted in directing their agitation towards the disorganization and failure of cultural practice. The remnants of the unvanquished kulak class spread rumors that cotton carried malaria and that it was, therefore, not worth while bothering about. They also told the population that cultivation of cotton fields after planting was unnecessary, since the weeds kept the plants warm, and so on.

The large percentage of cotton losses on the kolkhozes may be explained to a very considerable extent, by their unsatisfactory arrangements for organizing their work, and especially by the bad distribution

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of workers among the permanent production brigades, the absence of personal or group responsibility for specific areas in cotton planting and the equalization of wages, which had a pernicious effect on the continuing processes of cultivation. Production was also unfavorably influenced by the ignorance of regional and local organizations, who did not understand the proper method of using state advances against cotton, in goods and money, as a means for stimulating the collective farmers to better tillage of the cotton fields; and even, in a number of places, criminally diverted cotton funds from their designated purposes.

An immense amount of damage was also done to the development of cotton growing in the new areas by the opportunistic underevaluation of cotton in a number of rayons and MTS. Some workers of the krays, rayons and MTS adopted the entirely incorrect view that cotton was a crop of the second grade, to which they owed less than to other crops. This was the origin of the neglect of the most elementary rules of cotton growing technique and the complete ignoring of mechanized methods of producing this crop by a large number of rayon organizations and MTS.

Some of the local workers try to justify this opportunistic underevaluation of cotton by reviving the famous theory, long since buried as not corresponding to reality, that cotton growing is impossible and unprofitable in the new regions. But they fail to understand that "we cannot look at profitability in a mercantile way, from the point of view of a given moment. We must consider it from the point of view of the whole national economy, over a number of years. Only such a point of view can be called truly Leninist, truly Marxist. And this point of view is obligatory not only in relation to industry, but, to an even greater degree, in relation to kolkhozes and sovkhozes." (Stalin).

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The data from the experiment stations located at different points in the new regions emphasizes the high yields that are possible with proper management. Such stations have consistently obtained yields ranging from 10 to 15 tsentner per hectare, year after year for a number of years, from very considerable acreages. These possible yields are emphasized as well by data from hundreds of kolkhozes that have obtained lint yields ranging from 3 to 9 tsentner per hectare. Thus, in Ukraine, the average lint yield in 1931 was 2.92 tsentner per hectare for the total planted area of 144,500 hectares; but a number of kolkhozes obtained yields two to three times higher than this average.

LINT YIELDS OF KOLKHOZES IN 1931 and 1932

(in Tsentner per Hectare)

Name of Kolkhoz (1)	Rayon (2)	1931 Area Harvested (3)	1931 Average Yield Per Hectare (4)	1932 Area Harvested (5)	1932 Average Yield Per Hectare (6)
DAGESTAN					
"Krasniy Pakhar"	Achikulakskiy	20	4.6	75	3.3
"Vsem Druzhba"	Shelkovskoy	--	---	225	4.5
"Krasniy Partizan"	Baba-Yurtovskiy	--	---	35	5.9
NORTH CAUCASUS KRAY					
"Zavet Il'icha"	Mozdokskiy	600	4.0	460	4.0
"Krasniy Sunzhenets"	" "	---	---	180	8.67
"Krasniy Oktyabr'"	Petrovskiy	255	4.0	150	8.92
"Oktyabr'"	Prikumskiy	---	---	200	6.82
CRIMEA					
"Krasniy Boyets"	Dzhankoyskiy	10	7.5	--	--
"Leninets"	Simferopol 'Skiy	128	5.6	--	--

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(1)	(2)	(3)	(4)	(5)	(6)
UKRAINE					
"Perebulova"	Golopristanskiy	140	8.0	425	4.8
"Pyatirichka"	Skadovskiy	876	8.0	---	---
"Peremoga"	Kakhovskiy	279	5.2	---	---

In 1933, which enjoyed less favorable meteorological conditions for cotton than the preceding years, a number of kolkhozes that conscientiously tilled their cotton fields obtained excellent yields. Thus, for instance, in North Caucasus, the kolkhozes of the Arzgir MTS harvested 2,918 hectares in cotton and obtained yields ranging from 4 to7 tsentner per hectare; the kolkhoz "Krasniy Suzhenets" in Mozdokskiy Rayon harvested 280 hectares and obtained a yield of 10 tsentner per hectare from its 20 hectares in cotton. In the Ukraine, the Skadov Khlopkosovkhoz had 4.9 hectares in cotton, which, being tilled properly yielded 5.8 tsentner per hectare.

Thus these selected data on the productivity in raw cotton in different kolkhozes in the cotton zone of the new areas, with different climatic conditions, and for different years, prove that it is entirely possible to obtain satisfactory unit yields of cotton in the new regions, in any year, without irrigation and at a considerably lower labor cost than in the irrigated areas. These data completely destroy the opportunistic unbelief and the theory of the well-known saboteur Zaytsev, the agronomist Bushuyev and their followers to the effect that cotton growing in the new areas is scientifically fantastic, since the natural environment does not meet the biological requirements of the cotton plant.

It follows from all that has been said above that cotton is becoming entrenched in the new areas. A new and mighty cotton producing

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base is being established in the new areas of the south of the European part of the USSR, to supplement the main cotton base of the USSR in Central Asia and Transcaucasia. Today the most northerly cotton growing in the world is being carried on in the new areas of the USSR, where the cotton plant has advanced up to the 48th parallel of north latitude, while in most of the old cotton growing regions of the world it is distributed between the 41st and 42nd parallels.

The successes achieved in the development of cotton growing in the new areas are consequences of the following:

(1). The fundamental social and economic reconstruction of the agriculture of the new regions, on the foundation of the widespread development of the sovkhoz construction, the gigantic growth and strenghtening of the kolkhoz movement, and the liquidation of the kulaks as a class, which allows reconstruction based on solid and unbroken collectivization.

The new cotton areas, consisting of North Caucasus, Crimea, the former Lower Volga and the Ukraine, are the advanced areas of solid collectivization in the USSR, in which the collectivization of peasant farming was substantially completed by the end of the first Five Year Plan.

(2). The increasing technical equipment of the sovkhozes, and also of the kolkhozes through the MTS, based on the far-reaching success in the industrialization of the country has aided development of the cotton growing industry.

(3). The determined struggle against the opposition of the class enemy to the introduction of cotton growing in the new areas, and against the opportunistic disbelief in its possibility has been a

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help in the expansion of the industry.

(4). The existence in the new areas of immense tracts of land suitable for cotton growing without capital investment in irrigation works is a great advantage. As a general rule it is unirrigated cotton growing that is being expanded.

The achievement of cotton growing in the new regions takes on special significance in the light of the unprecedented crisis through which cotton growing in the capitalistic countries is passing.

During recent years, the acreage and harvests of cotton have been uninterruptedly declining in all the capitalistic countries.

Thus, for instance, in the United States, the cotton acreage in 1932 was cut down by 4,000,000 hectares to 14,500,000 hectares from its level of 18,500,000 hectares in 1929; and an imense number of farmers were ruined.

In British India, cotton acreage in 1932 was down by 2,100,000 hectares to 8,400,000 hectares against 10,500,000 hectares in 1929.

In Egypt, cotton acreage dropped in 1932 by 315,000 hectares to 459,000 hectares against 774,000 hectares in 1929.

In the capitalistic countries, cotton growing has been chased into a blind alley; curtailment of cotton acreage is proceeding, and the working masses are being impoverished. In the Soviet Union, cotton growing is expanding, new areas are being conquered in the struggle with nature, and the standard of living of the broad masses of workers and collective farmers is being raised to a higher level. Here are the two sets of consequences which have resulted from the activities of two different systems; the socialist and the capitalist.

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THE OUTLOOK FOR COTTON GROWING IN THE NEW REGIONS

The Party has set the task of increasing by two to three times, during the Second Five Year Plan, the level of supply of articles of mass consumption prevailing at the close of the First Five Year Plan. This task demands intensive development of light industry. "So grandiose a task during the period of a single Five Year Plan would not only be beyond the power of any bourgeois state, but it would have been beyond our own power during the First Five Year Plan." (Molotov: "On the Second Five Year Plan."). Only now, when our heavy industry, the key to the social and technical reconstruction of all branches of our economy, stands firmly on its feet at last- only now, when the socialist forms of economy have occupied the decisive positions in our agriculture, assuring the establishment of stable food-producing and raw material-producing bases for industry, is it possible to have a future rapid advance of light industry as well. The textile industry has one of the most important places among the varied branches of light industry. How will this branch be supplied with raw material during the Second Five Year Plan? In answering this question it is necessary first of all to bear in mind that a resolution of the 17th Party Conference contains a directive that the textile industry be assured of its raw material supply by doubling the total production of cotton by the end of the Second Five Year Plan. The fulfilment of this directive that the textile raw material supply be doubled must proceed primarily by way of increasing the unit productivity of cotton plantings. Central Asia and Transcaucasia, of course, have been the main cotton bases of the country, and they will doubtless remain so during the Second Five Year Plan. But along with these, the role of the new regions as new raw cotton bases of the Soviet Union must be very considerably augmented during the

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Second Five Year Plan. This state of facts, then, constitutes our point of departure for our examination of the outlook for cotton growing in the new regions.

"The solution of the problem of commercial cotton growing in the new regions represents a major achievement of the socialist Soviet system and has great economic significance. In the new regions, high yields of cotton are attainable without irrigation, and consequently without involving expenditures for capital amortization and maintenance of an irrigation system. There are the broadest possibilities for mechanization of cotton growing in the new regions, since it is limited neither by the extent of the flood charts nor by the local relief. All these conditions, to a very great extent, reduce the amount of labor required for production.

It must be added, however, that most sections of the new areas are located in a belt of insufficient moisture, subject to the annual recurrence of cruel dry winds, prolonged drought, and with a distribution of precipitation unfavorable to the spicate grains, such as corn and wheat." (From the book The Socialist Reconstruction of Cotton Growing" edited by A. M. Koktyn', 1934 edition.)

Cotton is one of the few plowed crops with a heavy taproot that can draw moisture from the deeper horizons of the soil and thus withstand the arid climate of the new regions. In many kolkhozes of the new regions, cotton is almost the only drought-resistant crop that can be used as the tilled component of the crop rotation. In the light of these data, cotton stands out not only as the most important raw material crop in the country, but also as an essential component of the grain cycle in the crop rotations of the arid zone of the Soviet Union with

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which the new cotton areas are related.

Cotton has been grown commercially in the wide zone of the new regions in the south of the European part of the USSR, located between 41 and 48 degrees north latitude and 31 to 50 degrees longitude east of Greenwich. The great diversity of the physical and geographical conditions in the zone and the specific nature of the climatic and soil requirements of cotton are responsible for the distribution of the cotton districts in the form of separate and distinct oases, frequently separated from each other by immense distances.

The location of these cotton-growing districts in the new regions is as follows:

The Dagestand district embraces the level portion of the republic, lying along an extensive stretch of the Caspian shore. It is divided into a northern steppe zone and a southern zone, which is more or less elevated and runs in the form of a narrow belt between the sea and the dissected relief of the foothills.

The Azov-Black Sea cotton district adjoins the Black Sea and the Sea of Azov and runs from Anapa to Yeysk. Its eastern boundary is rather indeterminate, and large-scale planting of cotton is being carried out in the approximate area of Slavyanskaya Station.

In the northern part of the Azov-Black Sea Kray, there is a district along the Don River, between Konstantinovskaya and Tsymlyanskaya Stations, immediately adjoining the unirrigated cotton-growing Rayons of Stalingrad Kray. According to analyses of the climate and data of experimental plantings, cotton growing is possible in this district.

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The North Caucasian cotton district occupies a rather extensive territory, and includes the Mozdokskiy, Vorontsovo-Aleksandrovskiy, Prikumskiy, Vinodelenskiy, Petrovskiy, and Blagodarnenskiy Rayons. On the south it merges into the level portion of the Chechin between the Terek and Sunzhey rivers.

The Stalingrad cotton district is composed of two parts: the irrigated cotton region, located in separate areas on the lower course of the Volga from the sea to Stalingrad, and the unirrigated cotton region, which is situated further north, adjoining the River Don and embracing the Nizhnechirskiy and Kotel'nicheskiy Rayons.

The cotton zone of the Crimea takes in only the flat central part of the peninsula, from the western shore of the Black Sea to the Kerch Strait on the east.

The northern boundary of the cotton zone of the Crimea runs from Ak-Mechet' on the west to Ak-Chekrak, Biyuk-Onlar, Ichki and thence along the railroad to Kerch City. Its southern boundary runs from the village of Nikolayev to Bulganyk, Sarabuz, Dzhalaby and through Old Crimea to Feodosiya.

The Ukrainian cotton district lies to the south on the shores of the Black Sea and the Sea of Azov, and extends from the western frontier of the USSR eastward to approximately the longitude of Mariupol'. Its northern boundary runs eastward from Zel'd to Severinovka, N. Odessa, Vladimirovka, and from there runs along the left bank of the Dnepr to V. Rogachik, descending thence to S. Terpeniya, then running in a narrow belt roughly parallel to the shore of the Sea of Azov in the direction of Berdyansk and Mariupol'.

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In their climate the new cotton areas belong to the semi-arid and arid zone of the USSR. In spite of this it should be noted that what is least available in the new areas is not water for the cotton plants, but heat. Thus, in the extremely arid year 1929, when most of the crops of the Taman peninsula literally burned up, the cotton fields "looked like green oases" and gave excellent harvests. On the other hand, in 1933 which was a very wet year, the development of the cotton crop was delayed in consequence and its productivity reduced.

The soil cover of the new cotton areas of the RSFSR and Ukraine is characterized by the prevalence of chestnut chernozems and chestnut soils of various shades, loamy in composition.

In the downstream areas of the Dnepr sandy loam soils of alluvial origin are prevalent (Golopristanskiy and Skadovskiy Rayons), which are more favorable for cotton. The preference is usually given to the loam and sandy loam soils, which are lighter in mechanical composition and more easily warmed through and are thus more favorable for cotton growing under the conditions of the new areas.

There is no uniformity among the cotton districts we have mentioned with respect to the degree to which natural conditions favor the development of cotton culture. In connection with this the Fifth Conference for Cotton Culture in the New Regions held in 1932, in its resolution divided the cotton areas into three groups or subzones, according to the degree to which cotton growing was favored by natural conditions, and on the basis of actual production to date:

a. "To the first group belong the areas which are unquestionably cotton areas and have the highest and least fluctuating productivity of cotton, and in which cotton is already the leading crop.

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b. To the second group belong the areas which are also unquestionably cotton areas, but have a lower productivity than the areas of the first group.

c. To the third group belong the areas with low and unstable productivity of spring crops, but with obvious primacy of cotton culture."

The first subzone is distinguished from the other two subzones by its higher temperatures, longer growing season and abundance of sunlight, which is very important for the development of the cotton plant. Experience has shown that in this subzone cotton culture gives the highest and least fluctuating yields, if harvested at the proper time. A greater proportion of the cotton is ripe for harvesting before the frosts, which accounts for the better textile qualities of the lint.

Cotton growing is most widespread in the regions of the first subzone. Natural conditions are less favorable in the second subzone, but sufficient to obtain a satisfactory yield of lint. Cotton has a conspicuous place on the cultivated fields of this subzone. The third subzone is coolest, and has a shortened growing season. Cotton culture here has a subordinate place among the other crops, with present techniques and varieties, and is confined to relatively small acreage, mainly on the lighter soils and on southern slopes.

METHODS OF INCREASING COTTON PRODUCTIVITY

"The central task of the Second Five Year Plan should be the decisive enhancement of the productivity of sovkhoz and kolkhoz fields" (from the resolution of the 17 Party Conference). There are very considerable material and technical prerequisites for the fulfilment of this task in the new cotton regions. While the cotton culture of the new

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regions was built up during the First Five Year Plan, largely by the mechanical application of the experience and technical methods of cotton culture in the old cotton areas, which brought a few agronomists to the point of actually rejecting the possibility of developing cotton culture in the new areas, these new areas will will, during the Second Five Year Plan, be armed by the new cotton technology, developed bythe experiment stations on the basis of concrete practical data obtained in the new regions.

The basic levers for raising the productivity of cotton in the new regions are (1) agricultural technology; (2) mechanization of cotton culture; (3) correct planning of the areas to be sown, and the organization of labor in the kolkhozes and sovkhozes.

CLIMATIC SKETCH OF THE NEW COTTON REGIONS

L. Ya. Apostolov

The new cotton regions occupy the large region in the south of the USSR from 42 to 47 degrees North latitude and from 31 to 50 degrees longitude east of Greenwich. If we include the points where trial plantings of cotton are being made, the cotton territory would probably extend to 48 degrees north latitude. the territory thus delineated, however, is not suitable for cotton growing throughout its entire extent, since natural and historical conditions within it are not uniformly favorable to cotton.

There are a number of separate blocks or districts in this territory, which constitute the independent cotton areas. They are as follows:

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The Ukrainian District lies on the shores of the Black Sea and the Sea of Azov and extends from the western frontier of the USSR eastward to about the longitude of Mariupol'; it extends to the 47th parallel in the north.

The Crimean District is located in the northern flat part of the Peninsula, in Leninskiy (Kerchenskiy), Feodosiyskiy, and Evpatoriyskiy Rayons and the western coastal part of Simferopol'skiy Rayon. The southern shore of the Crimean Peninsula does not belong to this District as it is given over to the cultivation of other valuable crops. The high mountain part is unsuitable in climate and soils, and the remaining level portions in the north of the peninsula (Dzhankoyskiy and the other Rayons) still constitute an experimental and exploratory belt, on which, however, the culture of cotton is entirely probable.

The Azov-Black Sea District adjoins the Black Sea and the Sea of Azov, extending from Anapa to Yeysk, while its eastern boundary is still rather vague. Cotton is extensively grown as far as about the meridian of St. Slavyanskoy.

The North Caucasus District is represented by the very extensive territory which includes a very considerable part of the steppes of the former Stavropol', Sal'sk and Terek Okrugs. From thence it meets the flat portion of the Chechen AO between Terek and Sunzhe.

The Dagestan District lies to a large extent on the Caspian Sea. It is divided into a northern steppe zone (to the north of the Terek River, with conditions similar to those in Prikumskiy Rayon) and a more or less elevated and dissected southern zone. This zone in turn is further subdivided into two parts: an eastern littoral belt, most of which is below sea level, and a western part with very complex relief,

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including not only plains but also valleys between the mountains.

The District of the (former) Lower Volga is located on separate parts along the lower reaches of the Volga from the sea to Yenotayevsk. It includes the extensive desert steppes of Kalmyk AO, where cotton culture, if it is possible at all, can only be under irrigation.

The Don District is located along the Don River from St. Konstantinovsk to Nizhnechirsk on the east and thence, to some extent, further along the Volga. The most favorable zone is around St. Tsymlyansk and St. Nizhnechirsk. The boundaries of this District are still far from being definite.

The physical-geographical conditions over such a vast expanse are very variegated and the climatic conditions are not uniform among the various districts.

THE DEPENDENCE OF CLIMATE ON PHYSICAL-GEOGRAPHIC CONDITIONS

The Ukrainian District is a lvel steppe, gently rising northward from the shores of the Black Sea and the Sea of Azov to an elevation of 120 meters at the 47th parallel. This belt may be divided into two parts by the structure contour 55 to 60 kilometers running east to west, from the central part of the Dnestr estuary on the northeast parallel to the seacoast at a distance of about 15 to 20 kilometers from it. At the meridian of Ochakov the structure contour increases its distance from the sea to 30 to 40 kilometers, passes to the north Nikolayev, crosses the Dnepr and runs towards Melitopol', whence it descends to the shore of the Sea of Azov, which it reaches near Berdyansk. On the right bank of the Dnepr this belt drops off sharply to the sea from cliffs 25 to 40 meters high. On the left bank of the Dnepr the steppe is

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almost unbroken by valleys or ravines. In general this part of the steppe is lower than that on the right bank, having an elevation of 26 meters above sea level at Bekhter, 13 meters at Brilevka and 25 meters at Askania-Nova, and gently descening southeastward to sea level at Sivash, where it forms low banks.

[The best places for cotton growing are on the left bank of the Dnepr, and embrace Golopristanksiy, Skadovskiy, Tsyurupinskiy, Genicheskiy and other Rayons, where climatic conditions are more favorable. There are also parts on the right bank, between Ochakov, Nikolayev, Kherson and Berislav where conditions are also entirely suitable for cotton; but these conditions deteriorate towards Odessa and Mariupol, since summer temperatures are lower there.]

Physical and geographic conditions are very complex in the Crimean cotton District. The Crimean Peninsula is entirely surrounded by sea, except for an insignificant part in the north, where it adjoins the Ukraine. There is a rather high mountain chain in the south of the peninsula, whith altitudes up to 1500 meters. Since the cotton zone lies to the north of these mountains, the influence of the warm, ice-free Black Sea is very much attenuated by the mountain ranges, which hold back the warm, humid southwest winds and cause them to leave the greater part of their moisture and warmth on the southern slopes, creating a subtropical environment on the southern shore of the Crimea. As far as the northern flatlands of the peninsula are concerned, the warm winds can more or less freely penetrate only as far as Leninskiy (Kerchenskiy) and Feodosiyskiy Rayons, where the mountains are still low (elevation 100 - 200 meters). They can also penetrate freely, in the western part of the peninsula, to Yevpatoriyskiy Rayon and the littoral part of Simferopol'skiy Rayon. These are the most suitable

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places for cotton growing. The influence of the Black Sea, however, is reduced to a minimum in the central steppe part of the peninsula (Dzhankoyskiy and other Rayons). The northeast winds freely penetrate there, strongly cooling the zone in winter and causing frequent droughts in summer. The Sea of Azov, on which these Rayons front, exercises only slight climatic influence since it is not large and has little water, and because its low, sandy shores, intensely heated by the summer sun, dry out even the air masses arriving after crossing the Sea of Azov. The Sea of Azov freezes over in winter, and is then a source of cold for all parts of the peninsula north of the mountains. In consequence, the climatic conditions are more severe in the north of the Crimea than on the steppes on the eastern Pri-Kuban shore of the Sea of Azov. The Crimean steppes are even less favorable climatically than the littoral Ukrainian steppes to the north, since the southern parts of the latter immediately front on the northern part of the Black Sea, which exerts a favorable influence by its warm mild climate. The temperatures in Northern Crimea are in general lower and precipitation somewhat less than in the Ukrainian littoral and in the Cis-Asiatic, Pri-Kuban steppes.

In view of the fact that the relief of the Crimean steppes is not that of a uniform plain, but is cut up by ravines and ledges, many points on this steppe expanse might be found to have a favorable comination of physical-geographical and microclimatic conditions, making cotton growing possible. The least favorable territory for cotton fronts on the Gniloye Sea, Sivash, which is separated from the Sea of Azov by the narrow Arbat reef and freezes over every winter. In the same way cotton cannot thrive in the northern part of the Crimean steppe, or where the altitude exceeds 150 meters.

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The Crimean steppes are very little blessed with regard to river systems or to water supply in general; the small river Salgir almost dries up in the summer, while the ravines and depressions are usually dry and only full of water in the spring. Soil moisture in the steppe part of Crimea is therefore lower than in the other cotton districts, for instance Ukraine and Taman, where the great valleys of the Dnepr, Bug, Kuban' and other rivers cut across the cotton areas.

The droughts in the steppe part of the Crimea are usually stubborn and prolonged, while the damage is accentuated even more by the dryness of the soil and the absence of river systems.

Sea of Azov - Black Sea District. The southwestern part of this District, where Anapskiy and Tempryukskiy Rayons are located, is strongly dissected. From the Tunnel Station, as from a mountain junction, the last spurs of the main Caucasus range radiate in three directions. The highest ridge (up to 500 meters) runs thence along the shore of the Black Sea and ends near Anapa City in the Lisa Mountain, a sheer drop down to the sea. To the north of this ridge, between it and a second ridge that runs northwest from the Tunnel Station, there is a valley where the kolkhozes of Natukhay and Rayev Stations are located. The microclimate of this valley has not been studied; it is closed off to both the warm southwest winds and the cold northeast winds. The second ridge is longer than the first one, and runs north from Anapa Bay, where it descends to the level of low hills (not over 60 - 70 meters) which cannot at all interfere with the propagation of the warming influence of the Black Sea. This line of hills thence penetrates further to the north and is observed even as far as Akhtar, Yeysk and Rostov.

Nearer to the sea, in the territory of this favorable influence, are the northwestern part of Anapskiy Rayon and the whole of the Taman

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Peninsula, which are the most favorable areas for the growth of cotton .

The third ridge runs north from the Tunnel Station in the direction of Krymsk and Verenikov Stations, where it turns right through the Kuban', forming the high right bank of the Kuban River on which Tempryuk City is located. East of this ridge, in the direction of Krasnodar, the conditions for the growth of cotton are considerably poorer. The extremeness of temperature here is increased as a result of the absence of any obstacle to the unchecked sweep of the northeast winds. Though they are somewhat weaker here, thay are considerably more prolonged. Late Autumn frosts and early spring fosts can occur, and there is a great fall in temperature during the summer nights. The dryness of the air is thus increased here.

The water systems are better developed in the Azov-Black Sea District. The Taman peninsula is divided into two almost equal parts by a great inlet from the Kerch Straits (up to 30 kilometers in length and up to 5 kilometers across). The territory adjoining the Taman Peninsula on the east is occupied by the broad delta of the Kuban' River, with numberous coves and a whole labyrinth of lakes, marshes, high-water ponds ("plavni") which occupy more than half of the whole area from Tempryuk to Akhtar. The culture of cotton develops favorably enough where soil conditions permit. The level of the high-water ponds and of the surrounding steppes is only very slightly above the level of the sea. These elevations are measured in single meters, and even between such relatively distant points as Starodzhereliyev and Krasnoaremeysk (formerly Poltava) Stations, the elevation of the steppe above sea level reaches only 7 meters.

The Cis-Asiatic shore rises from Akhtar north to the Don River, the high-water ponds disappear almost completely and the locality assumes

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the aspect of an exceedingly level chernozem steppe of 20 - 30 meters elevation, ending in a high abrupt shelf when it reaches the sea. There is no obstacle on allthis expanse to the unchecked sweep of the winds, which are hot and dry in summer, and very cold in the winter. The conditions for cotton are less favorable here than in the southern part, but its culture is still possible.

The North Caucasus District includes a more extensive territory than that of the Azov-Black Seas. In contrast to the grains and other crops, cotton develops more successfully here. It is even advantageous to plant it in those places of the District where the productivity is not very high. A few localities in Sal'skiy, Vinodel'nenskiy, Divniy, Blagodarnenskiy, Achikulakskiy and other Rayons belong to this category, together with the Don steppes north of Rostov. Cotton is fully successful south of the Kuma River, in Prikumskiy and Mozdokskiy Rayons, the central and southern parts of Dagestan, and that part of the Chechin flatland below the Terek (between Terek and Sunzh). In the west of this territory the boundary of cotton culture has not yet been determined. The elevation of the steppe and the degree of its dissection would appear to be limiting factors. Thus near Georgiyevsk the elevation of separate points reaches 400 meters, and under these conditions cotton can grow only on isolated spots in the valleys and on the low plains of Ingushetiya, Osetiya, and even the foothill localities of the Chechin and Kabardino-Balkar Oblast.

The area here with the best climatic conditions for cotton growing is that of Naurskaya (the eastern part of Mozdokskiy Rayon), where the elevation of the steppe is 20 - 30 meters above sea level. The warm southeast winds are able to penetrate freely to this area, passing between the sea and the main range of the Caucasus. The proximity of

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the mountains results in sufficient precipitation (400 millimeters and over). The combined influence of sea, mountains and steppes creates a great variety of climatic conditions; thus, in Mozdok, which is only about 100 kilometers west of the Maurskaya area, the mean temperature is already 1 degree lower, due to the fact that the Grebensk mountains, situated in Chechen, to the south of Mozdok, separate it from the warm southern winds.

The Chechen plain, between the Sunzhya and Terek and particularly that part of it which adjoins the Sunzhya, has a higher precipitation (about 500 - 600 millimeters) and a lower temperature (mean value 9 degrees), and therefore the part of the Chechen before the Sunzhya is less advantageous for cotton growing than the part below the Terek, around Mozdok and Naurskaya.

The Dagestan District is extraordinarily variegated. The territory between the Sulak and Terek rivers, where Khasav-Yurt and Akaay and Baba-Yurt Sovkhozes are located, appears most favorable. The elevation of this locality is 70 - 90 meters above sea level, with mean annual temperature 10.5 - 11 degrees, precipitation 400- 500 millimeters, and the frost-free period 200 - 210 days. These conditions result from the penetration of the warm Transcaucasian and Transcaspian air currents, moderated by the sea. In general this part of Dagestan may be compared in its good cotton climate to the Taman region, and it even excels the later in places.

On the other hand, the climatic conditions in the northern part of Dagestan are more severe and resemble those in the northern part of Prikumskiy Rayon; forsts in early autumn and late spring, very hot summers, but little precipitation during the growing season. This is

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all unfavorable for unirrigated cotton. The southern part of Dagestan fromMakhach-Kala to Derbent has peculiar conditions, there is much heat but only little precipitation, so that cotton growing here is mainly under irrigation.

In the northernmost part of North Caucasus Kray, at latitude 47 to 49 degrees, the Don District is located. This is the newest among the new cotton areas, and the situation here has still not been sufficiently clarified. Its best part is located on the Don River between Konstantinovka and Tsymlyansk Stations, and climatic conditions are sufficiently favorable. The advantageous qualities of the local topography apparently result fromthe configuration of the Volga and Don highlands, which somewhat attenuate the effect of the north and east winds. In this district, which has a considerably more severe mean annual temperature, summer conditions for cotton growing are nevertheless more favorable than in the more southerly semi-desert areas of Sal'sk, Mechetinskiy, Proletarskiy and other Rayons, where the dry winds attain very great force. Summer heat in Tsymlyanskiy Rayon is sufficient; mean summer temperature is 23.5 degrees and mean temperature during the growing season is 17.5 degrees. With proper tillage, cotton yields here are entirely satisfactory, as has been confirmed by observation and experiment during 1930 - 1932. There is no doubt that enough of these separate locations favorable for cotton can be found in the extensive Don District, which varies so widely by reason of its dissection by hillocks and river systems. Such possible locations may be found in Ust'-Medvedskiy, Dubovskiy, Oblivskiy and other Rayons, where temperature, precipitation and wind conditions, taken together, are sufficiently favorable and where trial plantings should clarify the relative suitability for cotton growing of the different rayons.

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THE CLIMATIC CONDITIONS NECESSARY FOR THE GROWTH OF COTTON

Before examining more in detail the climatic conditions in the new cotton areas, it is necessary to recall the climatic conditions whose absence makes cotton culture unproductive or even impossible. Research in this respect is still insufficient, for cotton has only been cultivated under irrigation in the new regions for 5 - 6 years in all, while conditions of growth here are in sharp contrast to those in Central Asia, Transcaucasus, America and elsewhere.

Based on the theoretical, experimental and practical data obtained up to the present time, we may set forth the following as the necessary minimum climatic conditions which the cotton plant demands:

1. Desirable temperature in June not under 20 degrees.
2. July or August should have temperatures of 23 degrees and higher.
3. May frosts are extremely injurious, especially if they occur after May 10.
4. Minimum night temperatures should not be low, since a minimum of 6 degrees in June and 9 degrees in July and August greatly stunts the growth of the cotton plant.
5. Mean diurnal temperatures in summer (June to August) should not be under, say, 21.5 degrees, and the mean temperature during the entire growing season (April - October) should not be under 17 degrees.
6. The length of the mean frost-free period, that is, from the last spring frost to the first autumn frost, should not be less than 170 days.
7. The mean annual precipitation for unirrigated cotton should not be less than 300 millimeters nor greater than 600 milimeters.
8. The optimum value of precipitation in May and June should be of the order of 40 - 50 millimeters, falling in the course of 3 or

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4 moderate rains.

9. Prolonged drizzles during the growing season are harmful.

10. Abundant rainfall, if not of prolonged character and if it is accompanied by high temperatures, during the May - July period is not harmful.

11. The end of August and especially the months of September and October should be dry, with optimum precipitation not over 20 - 30 millimeters.

12. Winter temperature makes no difference to the cotton plant; humid and snowy winters are favorable.

13. Prolonged droughts (over 30 days) in May, June and July are harmful. The degree of harmfulness depends to a considerable extent on the size of the soil moisture stocks remaining from the winter.

14. Prolonged and strong siroccos with very high temperatures and low humidity (under 20 percent) are harmful.

Bearing all this in mind, let us examine the distribution of meteorological values at various typical points in the cotton Districts, considering mainly temperatures and precipitation.

THE HEAT SATURATION OF THE NEW COTTON AREAS

Temperature and precipitation are the principal meteorological factors which characterize a given territory. Cotton as a very heat-loving plant is especially sensitive to temperature conditions, and any more or less considerable deviation from the limiting values on the lower

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side is injurious to its growth.

Most of the points where extensive plantings of cotton are being made in the new cotton regions have temperatures which more or less satisfy the basic requirements of the cotton plant (see table on pages 21 and 22 and Figure 1).

However, far from all of the points where exploratory plantings are being made have a sufficient heat saturation. Among such points to the north of the 47th parallel are Zinov'yevsk, Lugansk, etc. The further to the east, the more intense is the summer heat saturation, with relatively lower mean annual temperatures, as for instance, in Kamyshin and Ust'- Medveditskiy. Thus the possibilities of easterly points for cotton are more favorable than those of westerly points, since winter temperatures are almost irrelevant. The altitude and other physical-geographical conditions which define the local climate of the points in question inside the separate cotton districts may serve as obstacles to cotton growing. The southern boundary of the Northern Caucasus District traces an extremely tortuous line, bending around the foothills and wedging itself into the valleys.

The mean values shown in the diagrams, though very important in themsleves, still do not entirely solve the question of the suitability or unsuitability of the given points for cotton growing. It is no less important to know the other meteorological factors as well, and, in particular, their combinations, such as, for instance, maximum and minimum temperatures, the length of the frost-free period, the distribution and amount of precipitation, the weather at cotton planting and picking times, the minimum summer night temperatures, the humidity, winds sunlight, etc. Study of this side of the question has still not proceeded

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very far, and there is much that still remains to be revealed by a detailed study of the actual meteorological values and not merely of the mean values. The following facts may serve to illustrate this point.

The Taman Peninsula (Tempryuk, Khut. Sennoy) and the Central part of Dagestan (Khasav-Yurt), where climatic conditions for cotton are best, show both mean summer temperature and mean temperature during the growing season which are lower than in many other areas where the cotton plant grows considerably less well, as for instance in Petrovsk Village, Krasnodar, Slavyansk, Akhtaryakh, etc. At the same time the length of the frost-free period in Taman and Dagestan is greatest - 224 days in Tempryuk and 221 days in Khasav-Yurt; while in Petrovsk Village, Krasnodar, Slavyanskaya, Akhtari etc. it fluctuates from 174 days to 192 days. In Khasav-Yurt and on the Taman, summer temperatures are not as low as in Krasnodar and Petrovsk and in consequence cotton grows here without interruption and stunting. Autumn also lasts 20 - 30 days longer in Petrovsk Village and the other points than in Krasnodar, which also compensates for the insufficiency of high summer temperatures.

The North Caucasus District has entirely satisfactory summer heat, especially the Naurskaya Rayon, though the mean length of the frost-free period is only 190 days. The mean July temperature exceeds 25 degrees. Autumn is warm here, and hence this Rayon is also one of the best cotton areas, while the northern part of Prikumskiy Rayon, though it has a satisfactory amount of summer heat, also has early autumn frosts (sometimes at the end of September). Temperatures fall rapidly in October, and as a rule there are frosts and fine drizzling

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rains during the first ten days of the month , which strongly reduces the importance of these localities for cotton growing.

From diagrams 1, 2 and 3 of Figure 1, showing the annual march of temperature in typical points of the cotton districts, it will be seen that the eastern Districts (Astrakhan, Tsymlyansk and Naurskaya), where July temperatures exceed 25 degrees, have the hottest summers. The southern littoral area of Dagestan has a high mean annual temperature, but July temperatures do not reach 25 degrees.

In the western regions (Anapa, Taman', Crimea and the Ukraine), summer temperatures are considerably lower, being only about 23.5 degrees in July.

During the pre-planting period in the early spring , the western areas are warmer than the eastern. This difference disappears during April, and in May, during the time of planting and germination, the temperatures in the eastern areas are somewhat higher (from 0.5 to 1 degree) than in the western areas, while the western areas are considerably warmer in autumn, and for a more prolonged period, than in the eastern areas. The shortage of summer heat in the west is made up by the prolonged and warm autumn.

It is important to examine the curves of equal frost-free periods on the climatic map. Their direction does not entirely correspond with that of the annual isotherms, and in some places these two curves are even perpendicular to each other. This occurs to the east of the Sea of Azov, on the Taman Peninsula from Akhtari to Anapa, from Rostov to Krasnodar, in the eastern part of Crimea and around Yevpatoriya. In all these places the 220, 200, 190 and 180 day frost free curves are perpendicular to the 10 and 11 degree isotherms. The

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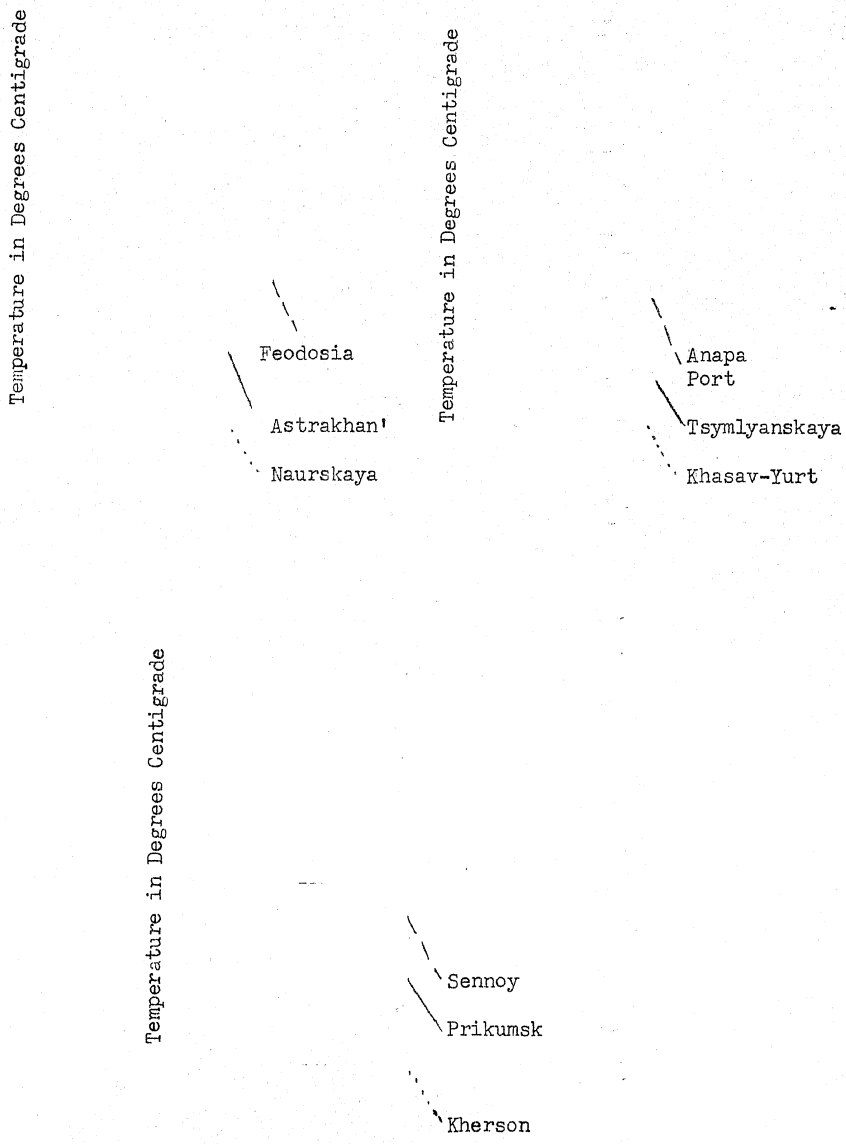

Figure 1. ANNUAL MOVEMENT OF TEMPERATURE IN TYPICAL POINTS OF THE NEW COTTON REGIONS

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nature of this territory is well characterized by these lines and their interrelations, taken as a whole.

The right angle between the 170 day frost-free and the 11 degree isotherm around Krasnodar indicates that killing frosts in May are still possible here even with high mean annual temperatures. The highest frost-free curve, that of 250 days, only takes in the Derbent area. This curve plainly represents the extreme northwestern advance of the Transcaucasian and Transcaspian curve. The 220 day curve takes in the better part of Dagestan with Khasav-Yurt and Baba-Yurt, while in the western Districts it takes the form of two ovals, one including the Taman' Peninsula and the southern part of Leninskiy and Feodosiyskiy Rayons, with the other and smaller oval embracing the Yevpatoriyskiy Rayon. The 200-day curve passes through the best cotton localities of the Ukraine from Skladovsk to Genichesk and then, crossing the Sea of Azov, runs south along the boundary between Slavyanskiy and Tempryukskiy Rayons and , passing to the east of Anapa, reaches the southern slope of the Caucasus Mountains. The 190 - 180 day durves pass through the cotton areas of the Ukraine, through Odessa and Nikolayev, cross the Sea of Azov and then descend sharply from Akhtari to the downstream areas of the Kuban' River and to Slavyanskaya Station, passing thence along the Trans-Kuban' foothills across Maykop to end in the foothills. In the eastern district the 190 day curve embraces part of Mozdokskiy Rayon, with Naurskaya as its center. This plainly represents the Transcaucasian branch of the curve. The 180 day curve runds along the northern boundary of cotton culture in the Ukraine, taking in Taganrog and Rostov on the north and thence descending towards Krasnodar and running along the foothils to Mozdok and Kizlyar. The 170 day curve mostly traverses localities of trial plantings and probable cotton areas. In studying these curves, we see plainly that they leave

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on the unfavorable side the entire northern part of the Kuban' steppes and parts of the former Stavropol'skiy, Sal'skiy and Proletarskiy Rayons. Separate ovals of the 180 day curve in Tsymlyanskiy Rayon and the 190 day curve in Prikumskiy Rayon are local in nature and result from special conditions which distinguish these localities from the contiguous territory. The cold northern part of Crimea is surrounded by an oval of the 170 day curve. Its origin may be explained by the fact that the shallow arm of the Black Sea which washes this part of Crimea represents an estuary of the Dnepr river rather than open sea, and freezes over almost every winter, just as the Sivash Sea to the east also freezes over rather early every winter under the action of the northeast winds; and so this narrow strip of the Crimea at the isthmus is subjected to a double cooling action which puts it into the class of the very cold areas.

The annual isotherms shown on the map have not been reduced to sea-level and thus show the actual mean annual temperatures. These isotherms are very tortuous, since they depend on the configuration of the mountains and follow their slopes. The isotherm of 12 degrees curves to take in only Derbentskiy Rayon, while on its western branch it passes somewhat to the south of Feodosiya and Anapa. The isotherm of 11 degrees cuts through Yevpatoriyskiy Rayon, proceeds on the southern slopes of the Crimean Mountains, thence via Feodosiyskiy, Leninskiy, Tempryukskiy and Slavyanskiy Rayons, loops around Krasnodar, bends back towards Novorossisk and goes on the Ozhen Slope of the Caucasus Mountains. In Dagestan, this isotherm of 11 degrees runs through Kizlyarskiy and Baba-Yurtovskiy Rayons, while the isotherm of 10 degrees runs through the best cotton areas of the Ukraine and crosses the Sea of Azov to enter the West Caucasian District near Yeysk, then making a great loop around the Kuban' River basin, turns again

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towards Novorossiysk and proceeds like the isotherm of 11 degrees to the southern sope of the Caucasus Mountains. The isotherm of 10 degrees enters the East Caucasus District from the sea, at a point to the north of Kizlyar, in the form of a separate loop, proceeds through Mozdokskiy Rayon, curves around and takes in Naurskaya, Grozniy, Cudermes and the region of Chechin below the Terek River, and then returns again by way of the foothills of Dagestan, to Transcaucasia.

Most of the remaining portion of the North Caucasus Kray, from the foothills between the Kuban' River and the Terek and as far as the Don River, as well as the northern part of Dagestan and the northern Cotton area of the Ukraine, is situated between the isotherms of 9 and 10 degrees. The isotherms of 8 and 7 degrees cross the northernmost parts of the territory, where only experimental plantings of cotton are being made.

It is clear from all that has been said that the mean annual temperature, taken by itself, is not the only index to the suitability or unsuitability of a given territory for cotton growing. The length of the growing season would be more suitable for this purpose, but, as experience has shown, it should also be taken together with other meteorological factors, including the temperature during the growing season.

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April (7)	May (8)	June (9)	July (10)	August (11)	September (12)	October (13)	November (14)	December (15)	Annual (16)	Mean Temperature During Growing Season from April 1 to November 1. (17)
10.0	16.1	20.2	23.3	22.9	17.8	12.9	9.3	3.9	10.3	17.6
8.9	17.5	21.3	23.8	23.2	16.1	10.7	4.9	-2.1	9.5	17.4
9.1	18.4	21.7	24.8	24.4	16.8	8.1	5.5	-4.9	9.1	17.6
10.8	17.6	20.9	23.2	24.1	18.0	11.8	7.3	0.4	11.1	18.1
10.5	17.1	20.8	23.3	23.1	17.5	11.5	6.8	-0.1	10.7	17.7
9.2	15.1	20.3	23.3	22.8	17.4	12.5	5.7	2.1	11.0	17.2
10.5	16.8	20.3	23.8	23.9	17.4	11.9	6.5	-1.1	10.2	17.8
8.3	15.2	20.8	24.1	23.8	17.2	11.0	5.0	-1.9	10.3	17.2
8.9	17.0	20.8	24.4	24.2	17.3	10.9	5.3	-2.2	9.7	17.6

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MEAN MONTHLY AND ANNUAL TEMPERATURES DURING VARIOUS LONG-TERM PERIODS
(according to data of the KRAYGIDROMETKOMITETA of North Caucasus)

Name of Point (1)	Coordinates and Elevation Above Sea Level (2)	Years Covered by Data (3)	January (4)	February (5)	March (6)	April (7)	May (8)	June (9)	
Anapa	Latitude-N. 44.54 Longitude-E. 37.19 Elevation 12.5	1924 - 1931	0.6	- 1.2	3.9	10.0	16.1	20.2	2
Yeysk	Latitude 46.39 Longitude 38.16 Elevation 20.0	1924 - 1931	- 4.5	- 6.0	0.1	8.9	17.5	21.3	2
Tsymlyansk	Latitude 47.45 Longitude 42.16 Elevation 18.0	1926 - 1931	- 5.4	-10.2	0.9	9.1	18.4	21.7	2
Krasnodar	Latitude 45.03 Longitude 38.55 Elevation 40.0	1925 - 1931	- 1.2	- 3.1	3.4	10.8	17.6	20.9	2
Slavyanskaya	Latitude 45.16 Longitude 38.08 Elevation 9.0	1924 - 1931	- 1.2	- 3.3	2.1	10.5	17.1	20.8	23
Kh. Sennoy	Latitude 45.12 Longitude 36.43 Elevation ---	1929 - 1931	- 0.4	0.2	3.9	9.2	15.1	20.3	23
Timashevsk	Latitude 45.37 Longitude 39.00 Elevation 21.4	1926 - 1931	- 2.7	- 6.8	1.4	10.5	16.8	20.3	23.
Ol'gino	Latitude 44.21 Longitude 44.20 Elevation 290.0	1925 - 1931	- 4.5	- 5.1	0.4	8.3	15.2	20.8	24.
Prikumsk	Latitude 44.45 Longitude 44.08 Elevation 105.0	1924 - 1931	- 4.7	- 5.8	0.6	8.9	17.0	20.8	24.

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April (7)	May (8)	June (9)	July (10)	August (11)	September (12)	October (13)	November (14)	December (15)	Annual (16)	Mean Temperature During Growing Season from April 1 to November 1. (17)
10.0	16.1	20.2	23.3	22.9	17.8	12.9	9.3	3.9	10.3	17.6
8.9	17.5	21.3	23.8	23.2	16.1	10.7	4.9	-2.1	9.5	17.4
9.1	18.4	21.7	24.8	24.4	16.8	8.1	5.5	-4.9	9.1	17.6
10.8	17.6	20.9	23.2	24.1	18.0	11.8	7.3	0.4	11.1	18.1
10.5	17.1	20.8	23.3	23.1	17.5	11.5	6.8	-0.1	10.7	17.7
9.2	15.1	20.3	23.3	22.8	17.4	12.5	5.7	2.1	11.0	17.2
10.5	16.8	20.3	23.8	23.9	17.4	11.9	6.5	-1.1	10.2	17.8
8.3	15.2	20.8	24.1	23.8	17.2	11.0	5.0	-1.9	10.3	17.2
8.9	17.0	20.8	24.4	24.2	17.3	10.9	5.3	-2.2	9.7	17.6

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(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)
Petrovskoye	Latitude Longitude Elevation	45.21 42.52 ---	1925 - 1931	-3.2	-6.1	0.9	10.0	18.0	21.3
Blagodarnoye	Latitude Longitude Elevation	44.45 43.30 *--	1925 - 1931	-4.5	-6.6	1.7	8.9	19.0	19.4
Divnoye	Latitude Longitude Elevation	45.51 43.21 ---	1925 - 1931	-5.0	-8.9	0.1	9.2	18.0	21.4
Prokhladnaya	Latitude Longitude Elevation	43.46 44.01 199.0	1924 - 1931	-3.8	-6.3	0.2	8.6	17.7	20.4
Mozdok	Latitude Longitude Elevation	44.46 44.40 118.5	1924 - 1931	-3.9	-5.9	1.2	8.6	17.2	21.1
Naurskaya	Latitude Longitude Elevation	--- --- ---	1926 - 1931	-3.6	-6.1	0.8	10.2	18.2	22.0
Khasav-Yurt[1]	Latitude Longitude Elevation	43.15 46.36 115.0	1912 - 1930	-1.2	-2.9	3.2	10.2	16.6	21.2
Makhach-Kala[1]	Latitude Longitude Elevation	42.59 47.31 32.0	1891 - 1930	-0.4	0.1	3.8	9.2	16.4	21.7
Achikulak[1]	Latitude Longitude Elevation	44.34 44.39 106.0	from 1896 and from 1911 to 1930	-3.9	-6.4	1.0	9.8	16.9	21.9
Kherson	Latitude Longitude Elevation	36.38 32.88 16.5	1905 - 1930	-2.6	-3.2	2.6	9.7	16.6	20.5

[1] Furnished for these stations by the GIDROMETBYURO of Dagestan

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(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)
Petrovskoye	Latitude Longitude Elevation	45.21 42.52 ---	1925 - 1931	-3.2	-6.1	0.9	10.0	18.0	21.3
Blagodarnoye	Latitude Longitude Elevation	44.45 43.30 ---	1925 - 1931	-4.5	-6.6	1.7	8.9	19.0	19.4
Divnoye	Latitude Longitude Elevation	45.51 43.21 ---	1925 - 1931	-5.0	-8.9	0.1	9.2	18.0	21.4
Prokhladnaya	Latitude Longitude Elevation	43.46 44.01 199.0	1924 - 1931	-3.8	-6.3	0.2	8.6	17.7	20.4
Mozdok	Latitude Longitude Elevation	44.46 44.40 118.5	1924 - 1931	-3.9	-5.9	1.2	8.6	17.2	21.1
Naurskaya	Latitude Longitude Elevation	--- --- ---	1926 - 1931	-3.6	-6.1	0.8	10.2	18.2	22.0
Khasav-Yurt[1]	Latitude Longitude Elevation	43.15 46.36 115.0	1912 - 1930	-1.2	-2.9	3.2	10.2	16.6	21.2
Makhach-Kala[1]	Latitude Longitude Elevation	42.59 47.31 32.0	1891 - 1930	-0.4	0.1	3.8	9.2	16.4	21.7
Achikulak[1]	Latitude Longitude Elevation	44.34 44.39 106.0	from 1896 and from 1911 to 1930	-3.9	-6.4	1.0	9.8	16.9	21.9
Kherson	Latitude Longitude Elevation	36.38 32.88 16.5	1905 - 1930	-2.6	-3.2	2.6	9.7	16.6	20.5

[1] Furnished for these stations by the GIDROMETBYURO of Dagestan

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(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
.0	18.0	21.3	24.1	14.0	17.3	11.4	5.8	-1.7	10.2	18.0
9	19.0	19.4	23.8	23.5	17.0	10.8	5.2	0.1	10.8	17.5
2	18.0	21.4	24.6	24.0	16.8	10.9	4.9	-2.5	9.5	17.8
5	17.7	20.4	23.2	23.6	17.5	9.9	4.8	-1.9	9.5	17.3
	17.2	21.1	23.9	23.8	17.5	10.4	4.6	-2.3	9.7	17.5
	18.2	22.0	25.0	24.8	18.3	12.5	5.5	-0.3	10.6	17.7
	16.6	21.2	24.0	23.5	17.9	11.8	6.0	0.9	10.9	17.9
	16.4	21.7	24.9	24.9	19.3	13.7	7.1	2.5	11.9	18.6
	16.9	21.9	25.1	24.4	18.0	10.6	5.5	-0.8	10.2	18.1
	16.6	20.5	23.1	21.9	16.9	10.4	4.7	-0.5	10.0	17.1

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(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
10.0	18.0	21.3	24.1	14.0	17.3	11.4	5.8	-1.7	10.2	18.0
8.9	19.0	19.4	23.8	23.5	17.0	10.8	5.2	0.1	10.8	17.5
9.2	18.0	21.4	24.6	24.0	16.8	10.9	4.9	-2.5	9.5	17.8
8.6	17.7	20.4	23.2	23.6	17.5	9.9	4.8	-1.9	9.5	17.3
8.6	17.2	21.1	23.9	23.8	17.5	10.4	4.6	-2.3	9.7	17.5
10.2	18.2	22.0	25.0	24.8	18.3	12.5	5.5	-0.3	10.6	17.7
10.2	16.6	21.2	24.0	23.5	17.9	11.8	6.0	0.9	10.9	17.9
9.2	16.4	21.7	24.9	24.9	19.3	13.7	7.1	2.5	11.9	18.6
9.8	16.9	21.9	25.1	24.4	18.0	10.6	5.5	-0.8	10.2	18.1
9.7	16.6	20.5	23.1	21.9	16.9	10.4	4.7	-0.5	10.0	17.1

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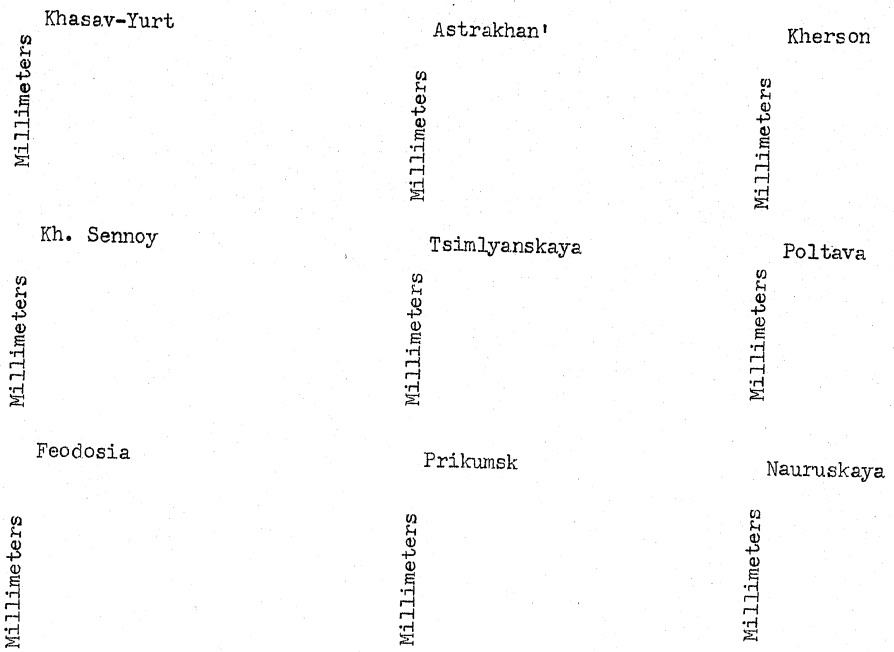

Figure 3. MONTHLY PRECIPITATION AT TYPICAL POINTS OF NEW COTTON AREAS

in that area is grown under irrigation. The reason for this is that on the Ukrainian seacoasts, though precipitation is light, the atmospheric humidity is usually high and summers are cool, while summer in Dagestan is very dry, even though temperatures are very high. Undoubtedly the eastern dry winds, which are more prevalent in Dagestan than in the Ukraine, also play a prominent part.

On the Kalmyk steppes and in the Lower Volga Kray, unirrigated cotton culture is doubtful at points with precipitation under 300 millimeters and with very hot and dry summers.

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PRECIPITATION DURING THE 45-YEAR PERIOD SINCE 1885, IN M
(According to data of KRAYGIDROMETKOMITETA of North Cau

Points (1)	Number of Years Covered by Data (2)	MONTHS January (3)	February (4)	March (5)	April (6)	May (7)	June (8)	July (9)	August (10)
Anapa	28	44	35	30	31	26	36	28	25
Achi Kulak	7 - 9	15	15	12	24	36	36	42	33
Blagodarnoye	5 - 6	16	16	20	26	43	46	33	33
Derbent	10 - 12	21	20	19	29	23	26	17	17
Divnoye	5 - 6	12	12	12	26	35	32	50	32
Yeysk	7 - 8	27	16	23	23	35	46	42	39
Kizlyar	17 - 19	20	17	16	25	31	39	32	29
Krasnodar	20 - 22	36	30	36	36	51	51	47	46
Makhach-Kala	31 - 33	36	28	26	31	30	39	29	35
Mozdok	5 - 6	12	12	12	30	33	45	36	30
Naurskaya	4 - 5	16	27	27	37	70	80	75	59
Ol'gino	12 - 13	13	13	17	24	44	60	44	34
Petrovskoye	5 - 6	33	19	24	33	52	61	67	52
Prikumsk	7 - 10	14	7	14	29	47	65	47	36
Prokhladnaya	10 - 12	12	15	18	34	67	86	52	42
Slavyansk	18-22	46	35	35	40	46	63	63	46
Taman'	7 - 10	25	30	25	42	38	34	34	30
Tempryuk	17 - 20	34	34	35	32	28	47	40	35
Timashevka	3 - 5	36	30	36	36	51	51	46	46

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N DURING THE 45-YEAR PERIOD SINCE 1885, IN MILLIMETERS
to data of KRAYGIDROMETKOMITETA of North Caucasus)

ONTHS

May (7)	June (8)	July (9)	August (10)	September (11)	October (12)	November (13)	December (14)	Annual Value (15)
26	36	28	25	31	38	41	51	416
36	36	42	33	24	18	21	24	300
43	46	33	33	26	20	23	26	328
23	26	17	17	52	44	44	39	351
35	32	50	32	30	18	15	21	295
35	46	42	39	46	27	31	31	386
31	39	32	29	38	19	25	25	316
51	51	47	46	36	46	41	56	512
30	39	29	35	57	42	48	48	449
33	45	36	30	30	21	21	18	300
70	80	75	59	48	38	32	27	536
44	60	44	34	24	20	20	24	337
52	61	67	52	43	33	24	29	477
47	65	47	36	47	22	14	18	360
67	86	52	42	36	26	24	19	431
46	63	63	46	52	40	58	52	576
38	34	34	30	17	51	51	46	423
28	47	40	35	39	39	43	44	450
51	51	46	46	36	46	41	56	511

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11
Khasav-Yurt	9 - 11	18	26	23	40	48	61	50	49	53
Kherson[1]	1900 - 1930	20	15	18	24	40	42	40	34	24

[1] Data for Kherson not fiven for the 45 year period.

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(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
61	50	49	53	42	35	36	481
42	40	34	24	30	27	27	341

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In consequence of the complexity of the physical-geographic conditions the isohyetal lines of equal precipitation shown on the climatic map represent a very interesting pattern. The mountains exert their influence toward the increase of precipitation, and therefore in Crimea and the Caucasus the higher valued isohyetal lines show marked displacement towards the north. The dry winds in the east reduce the precipitation, and therefore the lower valued isohyetal lines bend sharply and turn west. The influence of the winds overcomes the influence of the sea between the Don and the Stavropol' highlands, where these low isohyetal lines proceed further in a westerly direction. The winds, travelling further, then form a belt of reduced precipitation in Northern Crimea and the Ukrainian littoral. The isohyetal line of 400 millimeters forms a closed curve in the western cotton district, enclosing the entire Ukrainian cotton district, half of the Taman Peninsula and the Crimean cotton districts. In the eastern part of the cotton areas, the isohyetal lines of 300 and 400 millimeters proceed southward in the northern section, but when they approach the mountains they turn to the east and proceed further along the parallels of a latitude. The isohyetal line of 500 millimeters runs along the foothills of Dagestan and from the basin of the Kuban' River turns northward to Akhtari, and then descends steeply to reach the sea between Anapa and Novorossiysk. In Crimea 500 millimeters is noted only in a few points on the southern shore and in the mountains. Precipitation in the steppe part of Crimea is between 250 and 400 millimeters, while in the remainder of North Caucasus Kray it is between 400 and 500 millimeters.

The new cotton regions are thus sufficiently supplied with precipitation, especially in summer, since most of it falls in June and July, when the cotton plants need it the most. But this does not ex-

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clude the possibility of prolonged injurious droughts, which appear in allthe cotton districts without exception. Droughts in June and July are particularly harmful if accompanied by scorching dry winds.

Droughts last as long as 137 days, as for instance in the case of the drought in 1929 on the Taman Peninsula, from April 26 to September 12, during which time less than 30 millimeters of rain fell. Droughts lasting from 60 to 120 days are observed on the Crimean steppes, and in Dagestan there have been droughts lasting 97 days. At all points there may be whole months entirely without precipitation, not excepting even relatively rainy places like Krasnodar.

The more arid zone, or as it is customary to say, the semi-desert zone, is located in the northeast corner of the cotton districts in the former Sal'sk Okrug, in the northern parts of the former Stavropol' and Terek Okrugs and on the Kalmyk steppes, where droughts may last 3 - 4 and even 6 months. Droughts are often accompanied by dust storms that blot out the sun and carry dust in whole clouds for hundreds of kilometers. The wind sometimes tears away the upper plowed layer of the topsoil and scatters the plantings over very great distances.

The average frequency of droughts is as follows: droughts of 15 - 20 days occur every year, of 30 - 40 days, every three years,and over 40 days, every eight years. However, not every drought is harmful for cotton. If it lasts for 20 or 30 days in August and September and is not accompanied by dry winds, it is even beneficial to the cotton plant. As an example of a harmful drought we may cite the drought in all the cotton districts that lasted from the middle of July to 10 August 1930, when the temperature reached 42 degrees, the humidity fell to 15 - 20 percent, and wind velocities reached 10 - 15 meters per second. In

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this drought the cotton plants lost most of their buds, ovaries and leaves, a phenomenon which was especially marked in Prikumskiy Rayon.

Drought is the principal scourge for all crops in the new cotton regions and therefore the struggle with it should be vigorously waged in all the districts using all possible methods, even including artificial rain-making.

Violent downpours and rainy spells during the growing season are also harmful to the cotton plant, especially if accompanied by mists, slight cold drizzling rains or completely overcast skies. The cotton plant needs sunshine and gloomy weather stunts its development very much, delaying germination in May, delaying ripening in August and September, and retarding the opening of the bolls in September and October. Besides this, prolonged dryness may cause the bolls to rot. Severe downpours also damage the cotton plant, particularly during the period of germination. In June, July and August, however, as was obsered in 1931, they do no particular damage.

As an example of exceptional rains, we may mention the one which occured on 5 July 1931, when 118 millimeters fell in Prikumsk during a single day (24 hours), in August of the same year 124 millimeters fell in Slavyanskiy Rayon. To judge by the data of many years covering, in some cases, as many as 36 years, these instances apparently represent the maximum diurnal rainfall in the cotton regions. Such diurnal rainfalls occur on the average of once every 10 - 15 years.

There are sporadic downpours every year, but they usually do no damage, if unaccompnied by storms and hail. Slight hailstorms occur almost every year, with insignificant damage, but large hailstones killing 70 - 100 percent of the cotton plants fall no oftener than every 15 or 20 years.

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OTHER METEOROLOGICAL FACTORS.

Among the favorable meteorological factors should be mentioned the abundant sunlight in all the cotton areas. In the western districts the mean number of sunlight hours during the growing season reaches 1700 - 200, in the eastern districts 1600 - 1900 hours, and in Dagestan 1500 - 1700 hours. The most insolated points are Yevpatoriya, Feodosiya, Akhtari, Anapa, and the Taman' Peninsula. Ukraine, Prikumskiy and Priterechniy Rayons are somewhat less insolated, but in any case sunlight is entirely sufficient.

The mean number of sunlight hours during the summer is from 9.5 to 11.5 in the western districts, or from 75 to 90 percent of the possible number of sunlight hours, while this proportion is 65 to 80 percent in the eastern districts and somewhat lower in Dagestan.

WINDS

The detailed distribution of winds is till insufficiently studied. When we refer to winds, we mean the direction and velocity, both of which are usually observed by meteorological stations at altitudes of 9 - 12 meters. No data at all is available on wind conditions at the level of the cotton plant, since they have never been observed. However, wind velocities at these levels are considerably lower. Strong winds are very damaging to the cotton plant, and may do mechanical damage during the seedling period, as the plants are still not strengthened; during the blooming period winds may damage the flowers; but the most damage may be done during the ripening period, when the wind can unravel the lint and scatter it over a whole field. Strong, injurious winds of 14 to 20 meters per second occur at all seasons of the year and visit each point two or three times a year. If they are dry

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winds, they usually last 5 days during the summer, but during the winter half-year, especially during February, cold dry winds can last for months at a time, as occurred in February 1931. During the winter half-year, from October to April, the prevailing winds everywhere are from the east (65 to 70 percent), while during the summer half-year, from May to October, they are from the southwest (50 to 55 percent) in almost all regions, which does not exclude the possibility of prolonged dry winds in summer as well. In the northern parts of the eastern cotton districts, east winds prevail both in summer and winter.

The configuration of the locality has a strong influence on the movements of the winds. In Dagestan the mountains run from southeast to northwest, and under the influence of this direction the east winds are shifted to come from the southeast, in Mozdokskiy Rayon the majority of the winds blow from due east, while in Taman, Crimea and Ukraine they are most frequently from the northeast.

Wind velocities at different points have very great variations. They are lower in summer than in winter, and the difference amounts to approximately 25 percent of the mean annual velocity. There are very strong winter winds on the Taman Peninsula, reaching velocities of 5 - 6 meters a second. Wind velocities are somewhat lower on the Crimean steppes (4.5 meters a second) and in Yevpatoriya and Kerch (4.4 meters a second). Winds are also very strong in Dagestan; mean velocities are 5 meters a second in Achikulak and 5.8 meters a second in Makhach-Kala. They are somewhat weaker in Prikumsk and in Mozdok Rayon - from 4 to 4.5 meters a second - but are far more prolonged. The strongest and most prolonged winds blow across the great territory between the Don River and the Stavropol' highlands. This is explained by the extreme flatness of the terrain and the absence of any natural obstacle to the sweep

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of the winds. It is clearly shown on the climatic map how the isohyetal lines and the lines of equal frost-free periods bulge to the west under the influence of these winds. The winds reach the Sea of Azov and are usually especially strong near Akhtari. Then, crossing the Sea of Azov, they cool the northern part of Crimea. Climatic conditions become worse over all this expanse and are somewhat less favorable than in the places to the south (south of Tikhoretskaya) and to the north (north of the Don). Cotton is therefore not widely cultivated here. The lowest wind velocities are noted in Krasnodar and Slavyanskaya, where the mean annual velocity is 3.2 meters a second and the mean velocity /Possibly printer's error for "mean summer velocity"/ is 2.5 meters a second.

To recapitulate, we may arrange the cotton regions in the following order with respect to favorability of climatic conditions: Very Favorable; Taman' Peninsula, Anapskiy Rayon, Naurskaya and the part of Mozdokskiy Rayon below the Terek, the central part of Dagestan, Yevpatoriyskiy, Feodosiyskiy and Leninskiy Rayons in Crimea, the left bank littoral part of Ukraine between Skadovsk and Genichesk (very wide at Skadovsk, very narrow in Khorlovskiy Rayon and somewhat broader again towards Genichesk). These areas are characterized by frost-free periods of 200 to 225 days, mean annual temperatures of 10 - 11 degrees and annual precipitation of 250 to 460 millimeters, with most of it falling during the summer. The first half of autumn is dry and warm, and there are no killing frosts in May or September. Strong winds and the possibility of drought belong on the negative side of the balance sheet.

Favorable; In the Ukraine; the belt from Ochakov through Nikolayev, Kherson and Melitopol' to Nariupol'. In West Caucasus: Slavyanskiy Rayon, parts of Primorsko-Akhtarskiy and Yeyskiy Rayons, Tsymlyanskiy

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Rayon and many places in Dagestan. The frost-free period is 180 to 200 days, the mean annual temperature is 9 - 10 degrees, and the annual precipitation 350 - 500 millimeters, with most of it falling during the summer. Killing frosts are very infrequent and insignificant in May, autumn is cool, with possible rains, autumn killing frosts begin on the average about October 12.

Least Favorable; that part of the Ukraine north of the 47th parallel, the Don cotton district from Beshenskaya to Kamyshin, Krasnodarskiy and Timashevskiy Rayons, the northern rayons of the former Stavropol' Okrug (Divnevskiy and Proletarskiy Rayons), the northern part of Dagestan, and the elevated parts of the mountainous regions.

The irrigated cotton regions (Lower Volga and Dagestan) are very rich in summer heat and have a sufficiently long frost-free period; 170 to 180 days in Astrakhan and 220 to 250 days in southern Dagestan. Summer rains are trifling in amount - less than 100 millimeters in Astrakhan- but are very considerable in Dagestan - 300 to 400 millimeters.

We may say in conclusion that meteorological science has not yet spoken its last word on the question of the posibility of cotton growing in the new regions.

Though this question may be more or less settled for the large continuous cotton districts, things are considerably less clear with respect to separate details, and we may still find separate territories and separate tracts, more or less considerable in size,which can be used for the further development of cotton growing, as we have seen in the example of the Don cotton district.

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In the general complex of meteorological factors, taken as a whole, some climatic defects, such as temperature, for instance, may be compensated by others, such as humidity, sunlight and so forth. It is therefore entirely probable that the cotton districts will be considerably expanded in the near future.

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COTTON AND WEATHER IN THE NEW AREAS

(A report to the VI Conference for Cotton Growing in the New Areas, held at Prikumsk in July, 1933.)

by S. D. Lysogorov

The dispute as to whether cotton growing is possible in the new areas and in particular, in the Ukraine, which occupies the northernmost position among the cotton areas in the world, has lost all basis and practical significance by now, for during the last few years cotton has assumed a firm position here as one of the leading crops, and its acreage is counted in hundreds of thousands of hectares.

In areas where, according to the formulas of the saboteur Zaytsev, the cotton bolls could not possibly open under any circumstances before the autumn frosts, it has been shown possible to obtain, year after year, very reliable yields of lint of the order of 5 to 8 tsentner per hectare, and higher.

From this it is clear how completely unfounded it is to mechanically apply conclusions about the relation of cotton growing to climate, conclusions obtained under the conditions of the old cotton regions, to regions where the totality of climatic conditions is sharply contrasted with those of the old areas and where cotton growing, moreover, is based on entirely different and peculiar methods of agricultural technology.

The interest aroused by the clarification of the behavior of cotton under the climatic conditions of the new areas is thus entirely natural, and an evaluation of the probable productivity of that area among them which is least supplied with heat (Ukraine) is likewise

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important, since heat is indisputably the factor among all other meteorological elements which is most potent to limit the practical economic possibilities of cotton culture.

It may therefore fairly be awaited that here, of all places, in these territories where we have conquered nature and won new fields for cotton growing, the dependence of its cultivation and productivity on meteorological factors should be most clearly and concisely explained.

The practice of cotton growing in the new regions - including the Ukraine - during the past few years, has very definitely demonstrated that the primary prerequisite is not so much a matter of weather conditions as it is of agricultural technology. For failure to meet the fundamental demands of agricultural technology is the reason for instability of yield and sometimes even crop failure, and in general, for the immense gap between the size of actual cottom crops and the size of those which the weather and other natural conditions here would permit us to obtain.

It is our urgent task for the near future to liquidate this gap and reach a high productivity with the aid of the accomplishments of science, a task of which the solution lies in the organizational economic and political strengthening of the sovkhozes and kolkhozes.

But the significance of meteorological factors in cotton growing is still very great, even where the demands of agricultural technology are met.

The dependence of cotton growing on the totality of meteorological conditions and on the individual components of that totality must be carefully sketched in detail against the background of uniform agri-

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cultural technology, consistently maintained from year to year. And the same must also be expected even where sowings of cotton are made at different periods within the same year.

Experimental sowings of cotton have been made since 1924 in the northern zone of the New Cotton Areas on the territory of the Ukrainian Zonal Station (Kherson). Data is thus available covering a period of 8 to 9 years, and it already allows us to draw very definite and valuable practical conclusions in a number of instances as to the relation between the productivity of cotton and the meteorological conditions of the year.

Among these eight to nine years there are some with vividly contrasting meteorological conditions, and contrasting as well in their respective productivity of cotton. This is a premise favorable to the elucidation of the relations and interdependence which are of interest to us.

It must however be remembered that a connection so manifested does not in all instances necessarily prove to be the result of a causal sequence. Two phenomena are not infrequently associated only by external linkage, and simultaneously bear a causal relation to a third phenomenon.

Comparison among themselves, with respect to meteorological conditions, of entire growing seasons or of their separate stages, each of considerable length, such as for instance germination-flowering, budding-flowering or flowering-ripening, could not reveal many critical moments in the life of the cotton plant. For this reason the statistical method of analysis of the correlation between climate and growth must necessarily be supplemented by direct experiment to clarify the relation of growth to the specific meteorological factor being investigated.

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Work with the vegetative and laboratory-field methods of agro-meteorologyis just starting to develop, so that in a number of cases the conclusions to be presented below must be regarded as only first approximations.

The characteristics of the correlation between weather and cotton growth in the new regions are of greatest interest in the data from the Ukrainian cotton planting zone, since this is the northernmost of the new regions.

Heat

In complete accord with the findings in the published literature on cotton (Lysenko, Miroshnichenko and others), a very close correlation has been observed under Ukrainian conditions (at Kherson) between rapidity of onset of various phases of development of the cotton plant and the temperature, the more rapidly does the cotton plant traverse the stages of its development, the sooner does the onset of maturation arrive. The truth of this statement has been demonstrated in general in all cases under investigation, by analysis of the weather and by analysis of the results of cotton sowings at different periods of the same year, and it is also true for each stage in the life of the cotton plant, taken separately, as is apparent from the following table.

There is the same close and regular correlation between the development of the cotton plant and soil temperature.

The general deduction from this data is that the warmer the year the shorter the period of development of the cotton plant from sowing to maturity; with variety 169 the length of this period fluctuates between 120 and 172 days according to temperature conditions, or a fluctuation reaching the very imposing value of 52 days.

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ATMOSPHERIC TEMPERATURE AND THE LENGTH OF THE GROWING SEASON OF THE COTTON PLANT

Years	1925	1926	1927	1928	1929	1930	1931	1932	Coefficient of Correlation
Mean temperature from germination to blooming.	20.9	22.5	22.7	21.2	21.0	18.1	22.6	21.3	
Number of days between germination and blooming	97	67	61	68	63	87	56	64	-0.66 = 0.13
Mean temperature from blooming to opening of the bolls	14.2	17.6	23.0	19.2	26.2	17.3	23.1	2.1.	
Number of days between blooming and opening of the bolls	58	66	45	54	43	56	54	54	-0.77 = 0.09
Mean temperature between planting and opening of the bolls	18.1	19.7	21.3	20.3	22.4	19.0	21.5	20.5	
Number of days between planting and opening of the bolls	172	143	127	133	120	164	130	133	-0.94 = 0.03

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This regularity noted in the cotton literature, however, proves on more detailed analysis of the data to be confirmed only in general. Instances of very considerable deviation from this regularity are by no means infrequent. Thus in a series of experiments with plantings of variety 1306 at different periods in 1932 the following results were obtained:

Date of Planting	Days to Budding	Mean Temperature During the Period	Aggregate Temperature During the Period
August 1	48	21.1 degrees	1012 degrees
May 30	42	20.9 degrees	880 degrees

It will be seen from this data that cotton planted August 1 took 6 days longer to reach the budding period than that planted May 30, in spite of the higher mean temperature and the considerably higher aggregate temperature during the later period. The reasons for this are partially revealed by analysis of the conditions of this experiment:

Date of Planting	Number of Days with Maximum Temperature over 30 degrees	Number of Days with Minimum Temperature under 13 degrees	Relative Humidity at 1300 hours
August 1	17	13	40.8 percent
May 30	0	2	56.4 percent

The delay in budding is evidently connected with the sharp upward and downward deviations from the mean in the diurnal march of temperature, as well as with the reduction in relative humidity during the daylight hours.

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In another experiment with variety 1306 in 1931, the following data were obtained:

Date of Planting	Number of days to Budding	Mean Temperature During Period	Aggregate Temperature	Number of days with Maximum Temperature over 30 Degrees	Number of days with Maximum Temperature over 35 Degrees	Number of days with Relative Humidity under 35 Percent
June 19	30	24.4	733	15	2	7
July 2	29	25.9	752	21	6	6

(Note: Low minimum temperatures did not occur)

Cotton planted on July 2, though it enjoyed a mean diurnal temperature 1.5 degrees higher than that of the earlier planting of June 19, still took almost the same time to reach the budding stage.

The relative retardation in the bearing of the July 2 planting must apparently be attributed to the extreme increases of temperature during the daylight hours. Obviously temperatures over 30 degrees, and perhaps over 35 degrees according to the readings in the meteorological booth do no accelerate, but rather tend to retard, the march of the processes connected with the formation and appearance of buds.

The injurious effect of high temperatures is even more apparent from the results of a 1931 experiment on Variety 1306 (at Kherson):

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Date of Planting	Number of days to Budding	Mean Temperature during the Period	Aggregate Temperature	Number of days with Maximum Temperature over 30 degrees	Number of days with maximum Temperature over 35 degrees	Mean relative Humidity
May 30	33	22.2	733.1	7	0	60.0
June 9	41	23.4	958.0	16	2	59.9

The retarding effect of high temperature is also confirmed by experiments performed in 1932 by the vegetative method of P. A. Yakhtenfel'd. Increasing the temperature of the air in the immediate proximity of the plant above 35 degrees and bringing it up to 40 degrees already resulted in marked retardation of the transition of the cotton plant to the reproductive state and noticeably increased the hieght of the first sympodium. (See the periodical Za Radyan'sku Bavovny, Numbers 10 - 12 of 1932, "The Bavov Vernalization", by P. A. Yakhtenfel'd.)

Frequent and sharp temperature increases to the limits when they begin to retard the development of the cotton plant do not appear to be characteristic of the new cotton regions. On the contrary, it is the weather in the old regions that manifests an abundance of high retarding temperatures to a very considerable degree, as is apparent from the long-term data for maximum temperatures at Kherson and maxima for shorter periods at Tashkent.

In spite of the fact that the absolute maxima are given for Kherson, while for Tashkent only the maxima are given for the periods of observation, which are usually lower that the absolute maxima, these data still who sharp rises in temperature to be customary in Tashkent.

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POINTS	MONTHS APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
Kherson	28.7	34.5	39.8	38.5	38.8	36.0	32.0
Tashkent[1]	34.6	40.1	42.1	42.6	42.0	37.6	34.7

[1] L. A. Molchanov, "A Contribution to the Question of the climatic Regional Distribution of the Cotton Area" (in Numbers 5 - 6 of Khlopkovoye Delo for 1925).

In the development of the cotton plant the phenomenon of the so-called temperature after-effect is observed. If high effective aggregate temperatures are accumulated during the early stages, then the later stages are able to proceed with lower aggregate temperatures, and conversely; thus in 1930 Variety 1306 required a total aggregate temperature of 968 degrees for the completion of the phase "blooming to ripening", in spite of the relatively low temperature of 17.3 degrees during this period, while in 1931 the same phase took an aggregate temperature of 1246 degrees, though this period, with a mean temperature of 22.3 degrees, was much hotter in 1931.

One of the main reasons for this phenomenon was that in 1930 a total of 1875 degrees of mean diurnal temperatures had already been accumulated, while the corresponding value in 1931 was only 1599 degrees. In consequence the phase "blooming to ripening" in 1930 took only as long as in 1931, in spite of the low temperature.

It should not be thought, however, that this temperature compensation proceeds beyond the levels of supplementary heat which are actually useful to the cotton plant. This would be untrue, even if only

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because the degree of reaction to any given factor may in general vary with concomitant variations in other factors. But in addition to such variations, changes in the norms of reaction to temperature conditions may also occur in consequence of the specific phenomena of after-effects.

It would, finally, be erroneous to assume that plants necessarily become charged with heat only under high levels of temperature. Thus in 1930, though most of the "planting-to-blooming" period was cool, there was still an increased aggregate temperature before blooming. Accordingly the phase "blooming-to-ripening" required a lower aggregate temperature, that is, this phase proceeded at an accelerated tempo.

But very low temperatures, if they occur on many days, can operate as an external factor to counteract this phenomenon completely and thus prevent its appearance, as was the case during the unusually cold year in 1933 in the Ukraine.

The regularity reappears if ineffective temperatures are excluded from consideration. The correlation between the aggregate temperatures during the planting-to-germination and the germination-to-budding phases during the planting times of Variety number 1306 in 1933 was as follows:

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Calculated as Usual	Excluding Temperatures of 10 Degrees and Below	Excluding Temperatures of 11 Degrees and below	Excluding Temperatures of 12 degrees and below	Excluding Temperatures of 13 degrees and below	Excluding Temperatures of 14 degrees and below
0.44	0.15	0.01	0.12	-0.04	-0.51

Excluding Temperatures of 15 degrees and below	Excluding Temperatures of 16 degrees and below
-9,54	-0.24

that is, the preparation for budding proceeds at temperatures above 15 degrees, and it is therefore natural that the exclusion of physiologically effective temperatures of 16 degrees should again reduce the inverse correlation.

The phenomenon of temperature after-effect is of more general occurrence than that of vernalization, since for instance cotton plants which have reached the budding stage under different temperature conditions manifest different stages of preparation for blooming and therefore require higher or lower aggregate temperatures after budding to reach the following stage of blooming, according to whether they have received lower or higher aggregate temperatures before budding. The same is also observed with other periods. Confirmation is given by the subjoined table, showing the coefficients of correlation between the aggregate temperatures of paired development stages in the life of the cotton plant. These calculations are based on data for various points in the new and old cotton regions, and the graph in Figure 4 (on page 39) vividly illustrates the correlation between the aggregate temperatures necessary for growth during the various periods of development.

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CORRELATION BETWEEN THE AGGREGATE TEMPERATURES OF TWO DIFFERENT STAGES IN THE GROWING PERIOD OF THE COTTON PLANT

PERIODS	Bashtanka, 1932 North Ukrainian Zone Variety King.	Kherson. Sowing in 1930, 1931 and 1932. Variety Number 1306.	Kherson. Annual Data from 1925 to 1932. Varieties Number 169 and Number 1306.	Brilevka, Ukraine. Sowing in 1930 and 1931. Variety Number 1306.	Gandzha, 1927. Variety Number 182.1	Boz-su. Sowings in 1926 and 1927. Variety Number 182.	Beyram-Ali, 1927. Variety Number 182.
Sowing to 4th leaf and 4th leaf to budding.....	--	--	--	--	-0.63	--	--
Sowing to budding and budding to blooming.....	-0.35	-0.37	--	-0.27	-0.5	-0.73	--
Sowing to budding and budding to ripening.....	--	-0.77	--	-0.65	---	---	-0.51
Sowing to blooming and blooming to ripening.....	-0.64	-0.72	-0.88	--	-0.56	-0.30	--
Germination to budding and budding to blooming.....	--	-0.48	--	-0.44	--	--	-0.08
Germination to budding and budding to ripening.....	--	-0.51	--	-0.59	--	--	-0.34
Germination to blooming and blooming to ripening.....	-0.62	-0.40	-0.87	---	--	--	--

[1] The earliest dates with physiologically ineffective temperatures have been omitted in calculating the coefficients of correlation.

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Thus the correlations between all these pairs uniformly retain the minus sign and in a number of cases reach significant values. This inverse correlation between two different periods of development indicates that the actual amount of heat required by the cotton plant during a given phase of development is not determined only by the nature of the plant itself, or only by the concrete circumstances of development during that particular phase, but is also determined by the conditions under which it developed up to the time in question. For this reason it is clear that the harmful isophase theory of Zaytsev, when applied to any period of growth, independently of the age of the plant and of the preceding concrete conditions of development, is shown to be insolvent, just as soon as it is applied to conditions radically different from those under which it was originally introduced.

The phenomenon of temperature after-effect, which appears under analysis by the method of graphic juxtaposition of "parallel observations" and by statistical methods, demands verification by direct experiment, but it also demands the most intensive scrutiny and the undertaking of special investigations (which have already been initiated), inasmuch as further study of its nature might render possible the complete control of the growing season of cotton and the use of that control to increase productivity.

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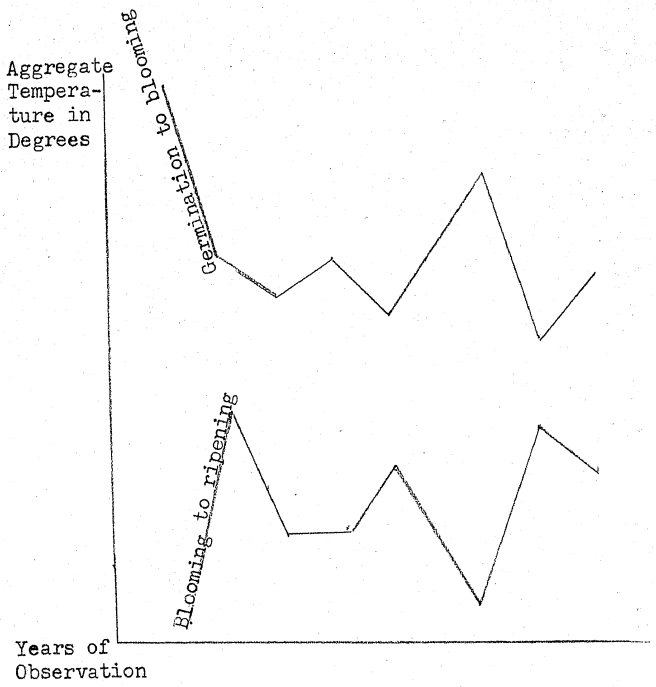

Figure 4. Aggregate Temperatures During the Periods Germination-to-blooming and blooming to ripening, of the Cotton Plant, Shown in their Relation to each other.

Soil temperature is also very important for the cotton plant. The works of K. V. Flerov and S. I. Yakubtsov (The Influence of Soil Temperature on the Development of Cotton, 1930) have thrown light on this question. But the work of NOVNIKhI in 1933 showed the exceedingly great importance of the relation between atmospheric and soil temperatures for the development of the cotton plant. A great gap between these temperatures retards development, stunts growth and may even cause death of the plant. The optimum atmospheric temperature for cotton plant development is thus correspondingly reduced where soil temperatures are lower, which involves some readjustment in our appraisal of the temperature conditions in the new regions. This is confirmed by the following results obtained in pot experiments at Prikumsk in 1933 with variety Number 1306.

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Place	Condition of Soil	Date Planted May 13	Date of Budding June 2	Mean Soil Temperature 28.8	Mean Atmospheric Temperature 30.7
Courtyard	Hot	May 20	July 23 dies	28.6	21.4
Courtyard	Warm	May 20	July 7	24.0	20.3
Courtyard	Cool	May 20	July 5	20.4	20.0

It is very important for a fuller description of the correlation between development of the cotton plant and the temperature conditions, to discover, even though only approximately, what limiting temperature must necessarily be exceeded if the processes preceding the appearance of the reproductive formations (buds) are to take place, that is, the minimum temperature required for the stage of vernalization under natural conditions.

It is well known from the work of Comrade Lysenko that the processes of vernalization begin almost as soon as the seeds start to grow, if the necessary conditions are present. It follows that if heat is sufficient, passage through the stage of vernalization can commence immediately after planting and the swelling of the seeds, before seedling emergence. Thus by analyzing the data on planting dates we may learn what levels of temperature during the period between the two plantings result in retardation of budding and consequently what temperatures may be utilized in the preparation for fruiting in the vernalization process.

The fact that the actual temperature conditions between two plantings are sufficient, by themselves, to influence the time when budding begins, is also confirmed by the correlations established between the aggregate temperatures in the periods between planting and budding in each case. Thus, for instance, the coefficient of correlation

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calculated for these values from data given in Lysenko's work Influence of Thermal Factors on the Length of the Phases of Plant Development proves to be equal to 0.92.

Analysis of the data by planting date given for various points of the Ukraine and Variety Number 1306 (see table on page 38) shows that under natural conditions the stage of vernalization of the cotton plant - based on temperatures shown by booth readings - may already proceed with mean atmospheric temperatures of the order of 18 - 36 degrees Centigrade.

Normal atmospheric temperatures at Kherson during May are 14.9 degrees during the first ten days, 16.8 degrees during the middle ten days, and 18.0 during the last ten days. Therefore the processes connected with fruiting of the cotton plant can already proceed from the middle ten days of May, and even on some of the first ten days. The relatively intensive stage of these processes can apparently be reached by May 21. And the actual retardation shown by sowings after May 20 is attributable as a rule to the sharp retardation of the budding phase as well, inasmuch as this can then not take advantage of useful temperatures. When sowings are made at the normal times, budding occurs toward the end of June, blooming commences towards the end of July or at the beginning of August, after which the cotton plant still develops for another month at temperatures over 20 degrees and begins to open its bolls in September, mostly during the second half of that month, with the temperature of the air still holding above 15 degrees.

The normal onset of frosts in the Ukraine and in all the new cotton regions is in the middle or the second half of October. It should be pointed out that these frosts, at least in the Ukraine , are

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ATMOSPHERIC TEMPERATURES AND STAGES OF VERNALIZATION OF THE COTTON PLANT

Name of Point and Year of Experiment.	Planting Dates	Highest Mean Temperature of Atmosphere (in Meteorological Booth) between these dates, in degrees Centigrade.					Budding Date	Retardation of Budding in Days
Kherson, 1932	May 5 and 20	17.5	17.2	17.0	16.5	16.2	June 27 and July 6	5
Brilevka, 1930	April 20 and 30	17.2	17.2	16.5	16.4	--	June 27 and July 1	4
Brilevka, 1930	April 30 and May 10	16.4	16.0	15.5	14.8	--	July 1 and 11	10
Brilevka, 1931	May 10 and 20	18.4	18.3	16.9	--	--	June 24 and 26	2
Skadovsky, 1932	May 5 and 21	18.2	16.9	16.5	15.9	--	June 30 and July 5	5

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usually accompanied by a general fall in the march of temperature, so that as a rule they apparently do not in themselves result in any large crop losses.

Let us now go further into the observed relations between the temperature conditions for the development of the cotton plant and its productivity, for which purpose the following table may be examined, together with the chart in Figure 5 (on page 42):

ATMOSPHERIC TEMPERATURE, LENGTH OF THE GROWING SEASON, AND LINT YIELD

Years	1925	1926	1927	1928	1929	1930	1931	1932
Mean temperature from sowing to ripening	18.1	19.7	21.3	20.3	22.4	19.0	21.5	20.5
Number of days from sowing to ripening	172	143	127	133	120	164	130	133
Harvest before the frosts, in tsentner per hectare	0	0	5.1	0.4	11.3	0.5	6.1	10.7
Total Harvest, in tsentner per hectare	0.9	1.8	8.8	5.4	12.2	4.0	14.5	10.7

There is an intimate relation between the productivity of cotton and the temperature conditions of the year; the warmer the year, the shorter the period between sowing and ripening, and the greater the harvest, both before the frost and the total yield of raw cotton. The correlation between the mean atmospheric temperature from sowing to ripening is expressed, for instance at Kherson, by the coefficient of correlation 0.87, while the correlation between the interval in days,

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between sowing and ripening, and the size of harvest is expressed by the coefficient of correlation -0.74.

Analysis of the data of past years, obtained under the conditions of the Ukrainian Zonal Station, indicates that total lint yields exceeding 5 tsentner per hectare, with about 0.5 tsentner per hectare, with about 0.5 tsentner per hectare harvested before the frosts, may be readily obtained under conditions analogous to 1928, which was characterized by the following indicia: mean atmospheric temperature from May to October was 17.6 degrees, from August to October 15.5 degrees, number of days with atmospheric temperature not lower than 13 degrees was 148, not lower than 15 degrees was 128, and not lower that 20 degrees was 66.

If we start from these figures, then of the total of 26 years with temperature data for Kherson studied by us, the following percentage of this number of years according to the various indicia must be assigned to the category of years with less than mean productivity:

According to mean temperature from May to October, inclusive...27 percent of these years.

According to mean temperature from August to October, Inclusive...19 percent

According to number of days with temperature no lower than 13 degrees-------15 percent

According to number of days with temperature no lower than 15 degrees -------11 percent

According to number of days with temperature no lower than 20 degrees-------11 percent

AVERAGE.....16.6 percent

It is clear from this that the indicia pointing to the probability of unfavorable temperature conditions, even in the most northerly

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zones of the new regions, are not great and even these relate to sowings of Variety No 169, with still far from complete application of the most recent achievements of agricultural technology. In the mean time we already have varieties of cotton that are much earlier and more productive than Number 169, while agronomic pra tice has also made great strides forward during the past two or three years.

At this point it wll be appropriate to give an evaluation of the temperature conditions for cotton in 1933.

Weather conditions for cotton in the Ukraine add up to an exceedingly unfavorable situation for 1933.

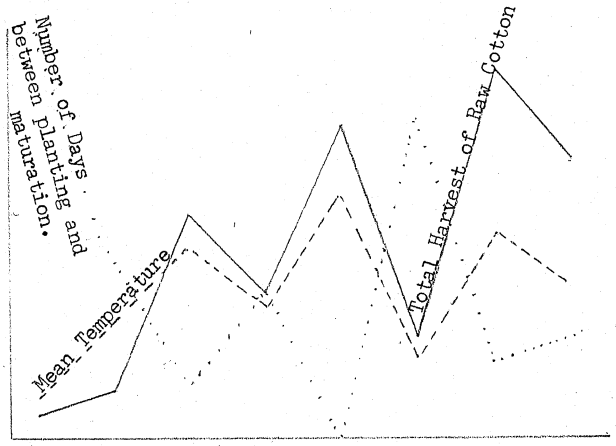

Figure 5. Total Harvest of Lint, number of days from Planting to Maturation, and mean atmospheric temperature during the growing season, shown in relation to each other (Data for Kherson).

All months without exception have been cooler than normal in the Ukraine, with average departures ranging from 1 to 2.9 degrees. If we compare 1933 with 1930, when weather conditions were the most unfavorable of all the years in which we have been growing cotton on a

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practical scale and the temperature indicia sharply deviated from normal on the bad side, then 1933 appears to be even more unfavorable, for all of its growing months were considerably colder than 1930, and in addition the first killing frost of autumn occurred almost half a month earlier than usual in 1933.

Sharp retardation was noted in allphases of cotton development in 1933, and the cotton plants were killed by frosts before they commenced to mature and open their bolls. This forced us to determine the frequency of seasons like that of 1933 by calculating the aggregate effective temperatures during the growing season for each such ten-day period from 1882 to 1933 inclusive. The temperatures included in the calculationwere those known to be physiologocally effective both for the initial and final stages of cotton development,and thus omitted all temperatures below 15 degrees.

The data were taken for Kherson, which is situated at the center of the Ukrainian cotton zone, and the following results were obtained:

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AGGREGATED ACTIVE TEMPERATURES NOT UNDER 15 DEGREES FOR TEN-DAY PERIODS DURING THE GROWING SEASON

(1) Years	(2) Sum of Ten-day Growing Season Temperatures of 15 degrees and Higher	(3) Years	(4) Sum of Ten-day Growing Season Temperatures of 15 degrees and Higher	(5) Years	(6) Sum of Ten-day Growing Season Temperatures of 15 degrees and Higher
1882	285.3	1899	323.6	1916	222.8
1883	312.8	1900	301.0	1917	260.5
1884	279.9	1901	303.7	1918	283.7
1885	328.2	1902	266.9	1919	245.0
1886	274.2	1903	312.3	1920	345.6
1887	297.9	1904	262.9	1921	278.9
1888	289.9	1905	332.8	1922	284.9
1889	313.9	1906	286.1	1923	294.5
1890	322.9	1907	295.1	1924	352.3
1891	316.1	1908	270.1	1925	273.7
1892	345.2	1909	332.0	1926	296.1
1893	301.0	1910	281.4	1927	303.1
1894	247.5	1911	258.8	1928	275.5
1895	278.0	1912	234.2	1929	301.6
1896	314.2	1913	253.8	1930	248.7
1897	333.0	1914	229.6	1931	299.3
1898	292.4	1915	278.8	1932	274.9

(Continued next page)

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(1)	(2)	(3)	(4)	(5)	(6)
				1933	197.3
Mean for 52 Years	----	----	----	----	288.4

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The mean long-term normal of this aggregate, for the growing season, is 288.44 degrees. The highest such aggregate was 352.3 degrees in 1924. The lowest was 197.3 degrees in 1933. Before that this value had never dropped below the 222.8 degree lead reached in 1916.

Similar results obtained by the calculation of other temperature indicia also point to the exceptional position occupied by the year 1933.

The percentage of summers with sharply depressed temperatures, that is with such aggregates not over 250 degrees, calculated on the basis of 52 years of observations, is 13 percent in all, including 1930 and 1933.

The year 1933 in its relation to cotton is unusual, and it is for this reason that the results of our agricultural technology deserve attention and are interesting indications of the accomplishments of our work; for, applying all the most important achievements of that technology, it was possible, even under these "impossible" weather conditions of 1933 for the Skadovsk base to obtain a yield of 5.8 tsentner per hectare of raw cotton from a field of 4.9 hectares.

Moisture

We turn now to the conditions of natural watering of the areas of cotton planting, and shall attempt to evaluate them, starting with these needs of the cotton plant for water, by the satisfaction of which an economically useful effect can be obtained. We shall therefore first of all explain, as far as the available data permits, the role of precipitation and soil moisture in the creation of the lint yield.

The direct juxtaposition of cotton productivity with the precipitation during the growing season, from Ukraine data, gives in general

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an inverse variation, however strange it may seem at first glance; the higher the precipitation, the lower the productivity. (See table and chart in Figure 6).

PRODUCTIVITY OF COTTON AND PRECIPITATION DURING THE GROWING MONTHS (MAY to OCTOBER)

Years	1925	1926	1927	1928	1929	1930	1931	1932	Coefficient of Correlation
Precipitation in millimeters	233	240	139	169	144	384	206	295	-0.33 -0.2
Lint Yield in Tsentner per Hectare	0.9	1.8	8.8	5.4	12.2	4.1	14.5	10.7	---

Note: 1932 had an excess of precipitation only in the beginning of the growing season of cotton. The second half of the growing season was exceedingly arid.

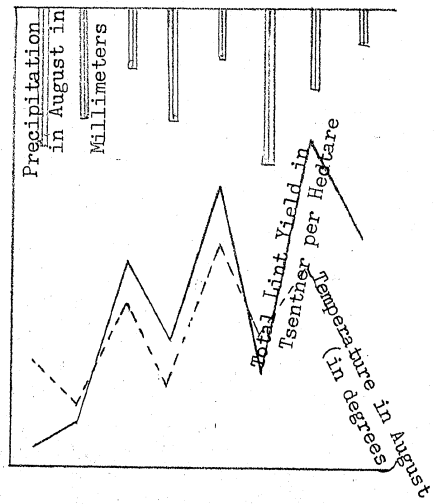

Figure 6. Lint Yield, Precipitation and Temperature in August (Data for Kherson).

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This phenomenon can be explained by the fact that wet years are as a rule cooler than dry years, while heat is one of the decisive factors for the outcome of the cotton season, so that its influence is more strongly reflected in the productivity of cotton than the direct effect of precipitation. Observations made over a period of two years on the territory of the Ukrainian Zonal Station and of its bases on the withdrawal of moisture from soil under cotton as compared with that in fallow, and also experiments on the immediate estimation of transpiration of cotton plants by the pot method, have shown that these plants use very little water during the initial phases of development, or roughly up to the budding stage. Nearer to the blooming period, the consumption of water increases, and sharply increases just before that period is reached, attaining a maximum with the flush of anthesis and boll formation. It subsides again as maturation approaches. If we assume that the critical period, with respect to soil moisture, in the development of the cotton plant, coincides with the period of most intense consumption of water by it, then we should expect to find that soil moisture conditions during this period had a powerful effect on the productivity of cotton. With rare exceptions (as in 1931) this period comes in August, under Ukrainian conditions. It would therefore be necessary to seek a positive relationship between August precipitation and the size of the harvest. However, Chart 3 (Figure 6) shows plainly that even in this case heat is more important for the cotton plant than moisture, since even here the precipitation still maintains its inverse variations with respect to the size of the harvest, while the distinctness of the positive correlation between mean temperature and harvest is still unimpaired. It is, therefore, entirely natural that in years with ample heat watering of the cotton plant at blooming time sharply increases the lint yield.

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In such cases , as is generally known from the work of the Ukrainian Zonal Station, the Brilevsk Irrigation Station and the Dagestan Zonal Station, irrigation can more than double the yield of the cotton plant, since in warm years, greatly resembling each other in thermal conditions, large cotton crops are obtained when rainfall is heavy during the growing season. The data on temperature, rainfall and cotton yield in the following table graphically illustrate and confirm this point.

PRECIPITATION DURING THE GROWING MONTHS AND YIELDS

	1927	1931
Mean Temperature from planting to boll opening	21.3 degrees	21.5 degrees
Rainfall from May to October, inclusive, in millimeters	128.5	205.6
Lint Yield in Tsentner per Hectare	8.8*	14.5

*This yield, which is with irrigation, is less than normal. Without irrigation it was even less - about 4 tsentner per hectare.

Direct juxtaposition of the lint yield and that of precipitation in those separate zones and subzones of the new regions which have most heat and least rain may be expected to reveal a positive correlation between them, and this work will be done on the basis of the data available when the appropriate stage of the study is reached.

The data for 1929 throw a certain amount of light on the question of the influence on cotton yields of considerable deviation of precipitation from the norm in single years. In that year 144 millimeters of rain fell from May to October, during the growing months of cotton. Based on many years' data, the norm in Kherson for this period is 210 millimeters. Thus in 1929 precipitation was 66 millimeters short of the normal for this period, which amounts to a deficiency of 31.4 percent, and yet the yield of cotton in that year amounted to 12.2 tsentner

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per hectare without the use of irrigation.

Among the factors participating in the growing of the cotton crop are not only the precipitation during the growing period, but also the presence of soil moisture stocks from the very moment of planting, and consequently also the precipitation that originates these stocks of soil moisture. In fact, if two years are selected, both with ample warmth, both with similar precipitation during the growing season, but different preciptation during the preceding autumn-winter period, before the planting, it will be found that the larger harvest is obtained with more abundant pre-sowing precipitation.

THE CONTRIBUTION OF PRE-COTTON-PLANTING PRECIPITATION TO THE SIZE OF THE RESULTANT HARVEST

	1927	1929
Precipitation during the pre-planting months of October to April, in millimeters.....	116.0	202.2
Spring soil moisture, in millimeters, in the top 1-meter layer of soil.....	162.8	220.8
Precipitation during the growing months of cotton in millimeters.....	138.5	144.0
Yield in tsentner per hectare.....	8.8*	12.2

Note: The partial increase of yield in 1929 as compared with 1927 must be attributed to better thermal conditions.

*See the footnote to the preceding table.

It is entirely natural that the role of the spring soil moisture stocks should vary with the quantity and character of precipitation during the growing season. In years when the cotton growing season is arid, the role of these stocks will increase, while on the contrary, in wet years, when rainfall is abundant during the period while the cotton plant remains in the ground, its role will diminish.

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To clarify the possibilities of obtaining cotton crops under conditions of extreme insufficiency of moisture, and also to clarify the role of the spring soil-moisture stocks, the following experiment was carried out in 1932. Cotton plants were isolated from the moment of germination, and also from the moment of budding, on separate plots 10.5 square meters in area, which were protected from the rain by portable plywood roofs during further development.

The roofs were put over the plots only during the rain. An area of supply 70 x 5 centimeters was assigned for each plant with the object of intensifying the shortage of moisture by overcrowding. Natural lateral infiltration of moisture into the soil proceeded at an exceedingly slow rate, which had been foreseen and demonstrated during the course of the investigations into the distribution of moisture in the soil of the boundary plot. After 45 - 48 days had passed since the beginning of the autumn rains, the amount of moisture at a point 30 centimeters inside the boundary of the plot was still unchanged from its value at the time of the September drought. This made it possible to place the plants under conditions of acute insufficiency of soil moisture even on the relatively small laboratory scale of the plots. The soil moisture stocks in the 1-meter top layer of soil amounted to 170.5 millimeters at the beginning of the experiment, with moisture in the 100 - 150 centimeter layer ranging from 7.0 to 7.5 percent.

The plants in the plot protected from the rain since germination showed clear signs of water starvation only very shortly before blooming. Towards the middle of August they began to wilt. Subsequently abscission of the fruiting formations was observed, but they nevertheless completed the full cycle of their development, reducing their

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yield by 26.2 percent as compared with the control - this under the arid conditions of the second half of the 1932 growing season - so that, calculated on the hectare basis, they yielded about 5 tsentner per hectare.

The opening of the bolls in the arid plot occurred 4 - 8 days sooner than in the check plot.

Thus, provided spring moisture stocks are sufficient, it is apparently possible, even if the precipitation during the growing period is considerably reduced, to obtain cotton harvests fulfilling the quotas set by the planned national economy. Under drought conditions, moreover, which are especially clearly expressed towards the end of the growing season, the bolls open earlier, but a certain deterioration of fiber quality must be noted when there has been no rain. Thus the fiber length was shorter than that of the control by 1.5 millimeters in the cotton grown on the plots protected from the rain since germination, while on the plots sheltered since budding it was 0.6 millimeters shorter.

At the present time profounder investigations are being made into the significance of precipitation and the surface stocks of soil moisture, using the same method of protection from rain by means of movable roofs (Kherson, Prikumsk, Taman'), and also the method of enclosing soil columns (monoliths) in isolation cells, assuring normal area of supply and approximately normal depth for root propagation; with the depth of some of these columns reaching 150 centimeters.

We dwell finally on the critical value of soil moisture, at which the normal nutrition of the plant is disturbed. Repeated observations made by us in 1932 on the territory of the Ukrainian Zonal Station on the soil moisture at times of acute water withdrawal symptoms of the

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cotton plant shows that this condition appears, as a rule, when Kherson soils (chestnut chernozem, humus 1.8 to 3.5 percent, subsoil normal, slightly sandy, rich in carbonate loess) are dried out to 6 - 7 percent, which represents about one and a half times the maximum hygroscopicity. However, after consuming the readily available stocks of moisture in the upper layers of the soil, the cotton plant freely develops by using the moisture in the deep layers below 80 - 90 centimeters For this reason it is possible that water starvation may not occur when the 0 -90 centimeter soil layer is dried out to about 6 - 7 percent, and in parts of it down to 5 and even to 4 percent (which is the ordinary maximum hygroscopicity of the cotton plant, provided there are still moisture stocks in deeper soil layers available for consumption).

This is confirmed by the results of soil-moisture observations on large tracts and by the following experiment. On an ordinary cotton field in full bloom, columns of soil, including the roots of a few growing cotton plants, were dug up. Each column had a cross section of 70 x 70 centimeters and a depth of 100 centimeters. They were enclosed in a cell having no bottom and left in an open pit, so as not to interfere with the natural connection between the column and the deeper soil layers. For months the cotton plants continued their normal growth in the columns. After the columns were cut away at the bottom, however, leaving them only 80 - 90 centimeters in depth, the plants suddenly commenced to wilt and die. The soil moisture in the columns after the undercutting was not higher than the coefficient of wilting.

These conclusions, based on the data of only a single year, need

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to be made more precise, as is being done by the current work of NOVNIKhI on agricultural meteorology.

The new regions enjoy a sufficiently favorable normal distribution of precipitation throughout the year, falling principally or in sufficient normalamounts in June, July and August, when it is most needed. Thus at Kherson, Kh. Sennoy, Prikumsk and Khasav-Yurt, the precipitation by months is as follows:

PLACE	MONTHS January	February	March	April	May	June	July
Kherson	20	15	18	24	40	42	40
Khutor-Sennoy	41	27	33	28	26	44	34
prikumsk	13	7	15	31	44	67	81
Khasav-Yurt	20	29	23	33	53	67	53

	August	September	October	November	December	Year
Kherson	34	24	30	27	27	341
Khutor-Sennoy	39	42	41	43	44	442
Prikumsk	37	41	23	19	15	393
Khasav-Yurt	48	51	46	36	36	498

It must be said of the May precipitation that it has a dual character. On the one hand, moderate moistening of the sown layer in May, during the period of the sowing and germination of the seed is useful; on the other hand, rainy weather in May reduces the number of working days during the strenuous planting period and delays its completion, while excess rain leads to the formation of incrustations and

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frequently also to subsurface packing. With the increasing disorders under these conditions, such as root rot etc., it leads to considerable mortality among the seedlings, unless corresponding agrotechnical measures are taken. Excessive precipitation is particularly harmful when it precedes the general emergence of the seedlings. The rains during the second ten days of May are an example of this in the Ukraine. The experience of 1930 and 1932 there showed that when rainfall increased to around 40 - 60 millimeters, it already became necessary to take energetic steps to control incrustation. To judge by the data of many years, however, all these harmful results of excessive May rainfall are relatively infrequent in the new regions.

We note that September droughts are especially characteristic of the Ukraine, before ripening and opening of the bolls. This tends to be on the whole advantageous rather than the contrary, since, as we have already noted, if soil moisture is insufficient just before ripening, the cotton plant begins to shed its leaves and accelerate the opening of the ripening bolls.

Finally, rain is harmful during the harvesting period, at the end of September and October, since it reduces the number of working days and also to some extent shortens the working day by causing mists and dews, increases the dampness of the lint and the probability of fungus infection and adversely affects its quality.

To sum up all the material on the relation between cotton and precipitation and soil moisture, the high degree of adaptability of this plant should be noted. It can react favorably to improvement in water conditions, but at the same time it is also able to reconcile itself to very severe deprivations of soil moisture and still give economically useful results.

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Taking all this into account, we reach the conclusion that all conditions in the new regions meet all the theoretical prerequisites for the development of unirrigated cotton growing as the fundamental background of their agriculture.

Sunlight is a very important factor in the development of plants in general, with not only the duration of insolation but its intensity and character (whether direct or diffused light) important elements for development and growth.

It is well known that a considerable section of the plant world is divided into two groups: the so-called "long-day plants" and "short-day" plants. The former category, as has been shown by T. E. Lysenko in his work Have Agricultural Plants an Intrinsic Photo-period Requirement? , require uninterrupted illumination for passage through one of their stages and can only adapt themselves to some degree of alternation of dark periods, while the latter category requires uninterrupted darkness for passage through one of their stages and similarly can only adapt themselves to a certain degree of alternation of light periods. Besides these two categories there is also an intermediate category that behaves indifferently to the alternation of light and darkness.

Cotton is a short-day plant. For this reason its northward displacement towards latitudes with longer days, into the new regions, should obviously of itself operate to delay boll formation if all other conditions remained unchanged. However the early varieties grown in the new regions are either completely indifferent to the greater length of the day or almost so. (H. Konstantinov, The Influence of the Length of

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the Period of Illumination on the Development of the Cotton Plant, 1930).

It is also pointed out in the agricultural literature that the assimilative processes of the cotton plant reach their maximum during the hours of most intense insolation and that cotton thus appears to be a typical sun-loving plant. (V. A. Novikov, A Contribution to Physiology of the Cotton Plant. Investigations into the Processes of Assimilation, the Dynamics of the Stomatal Apparatus and the Transpiration of the Cotton Plant.)

Parallel to the increased duration of insolation there is an improvement in the temperature regimen of air and soil, and the atmospheric humidity diminished with the increasing intensity of insolation and the rise in temperature levels. These factors act to accelerate passage through the stages approaching maturation (heat) and also mechanically accelerate the process of opening of the ripe bolls (atmospheric humidity and heat). It is of course obvious that clear sunlit days simplify cotton picking and keep lint quality at the proper level (dry, white, undamaged by fungus, etc.).

An experiment was carried out in 1932 on the territory of the Ukrainian Zonal Station to clarify the role of direct and diffused light in the development of the cotton plant and the harvest, even though only in the sense of furnishing very general orientation. The experiment consisted in growing cotton without direct sunlight, or with only restricted amounts of it (such as allowing direct sunlight only in the morning hours or only in the evening hours). The plants were shielded fromdirect sunlight by portable plywood roofs, set up at the height of the plants and taken from these plots for the other experiment only in rainly weather when all the sky was overcast. As a result the cotton

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plants deprived of all direct sunlight since inception of budding and limited exclusively to indirect light sent out fruiting branches but did not flower and yielded no crop. (Figure 7) Plants deprived of direct sunlight during morning and midday hours, or during midday and evening hours, gave only solitary blooms and exceptionally late at that; the incipient bolls did not finish their development and did not mature before the forsts, while all bolls in the control plots matured and opened before that time.

Finally, in those plants kept from full light since flowering by single and double layers of thin gauze, opening of the bolls was retarded and yield somewhat reduced.

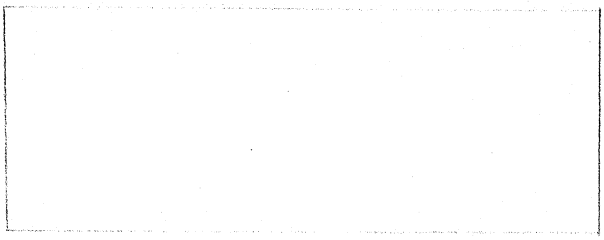

Figure 7. Plots, on which Cotton Plants Developed From Budding Time Without Direct Sunlight. These Plants have Leaves but no Open Bolls, while Bolls have Already Opened on the Controls.

In accordance with this, a direct correlation was established by mathematical analysis between the total duration of insolation in hours during the growing period and the yield of cotton. The coefficient of correlation between the total yield of raw cotton and the number of hours of insolation between August and October, inclusive, at Kherson (1925 - 1930) was 0.60; that between the pre-frost lint yield and the number of hours of insolation between May and October, inclusive, was 0.61. A very close direct correlation is also observed between the

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number of hours of insolation and the speed with which the various stages of development were traversed by the cotton plant.

Among the reasons for the positive influence of sunlight on the yield and on the speed of passage through the phases of development are the improvement in the temperature regimen in the plant itself, besides the well known reasons (the need of light for normal assimilation, etc.). Measurements of leaf temperatures in 1932 showed them to be much higher in plants receiving direct sunlight than in those hot receiving it, while the difference between the temperatures of insolated and uninsolated plants showed a regular daily march, rising towards midday and falling towards evening, like the amount of solar radiation itself. (Leaf temperatures were measured by thermometers with small mercury bulbs. The bulbs were placed flat against the leaves, which remained on the plants. See Geiger The Climate of the Surface Stratum of the Atmosphere on this method.), which difference was of the order of 4 - 6 degrees Centigrade for the midday hours

The data in the table show that the temperature of cotton leaves is much higher during the midday hours than that of the surrounding air, and that this temperature is already higher during the morning hours, while on the contrary, the temperature of leaves on uninsolated plants is lower throughout the whole day than that of the surrounding air.

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MEANS OF 4 OBSERVATIONS

TIME OF DAY	8	10	12	14	16
TEMPERATURES OF LEAVES ON INSOLATED AND UNINSOLATED PLANTS					
Temperature of leaves of insolated plants	19.2	27.0	31.2	33.5	31.0
Temperature of leaves of uninsolated plants	17.9	22.2	25.0	27.2	26.6
Difference	1.3	5.8	6.2	6.3	4.4
TEMPERATURES OF LEAVES OF PLANTS KEPT IN SHADOW AND OF THE AIR BETWEEN THEM					
Temperature of leaves of cotton plant protected from sun	17.9	22.2	25.0	27.2	26.0
Temperature of air between leaves	18.8	23.5	26.7	29.4	28.7
Difference	-0.9	-1.3	-1.7	-2.2	-2.1
TEMPERATURES OF LEAVES OF PLANTS ON OPEN FIELD AND OF THE AIR BETWEEN THEM					
Temperature of leaves of insolated plants	19.2	27.0	31.2	33.5	31.0
Temperature of air between them	19.0	24.4	27.9	30.7	29.3
Difference	0.2	2.6	3.7	2.8	1.7

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The though arises that the cotton plant may be able to utilize the thermal energy of sunlight. This idea has been noted in connection with a number of other plants in the general literature : Plant Life of Professor A. Kerner von Mariulan.

If this is really the case, then it is incorrect to calculate the thermal conditions of plant development only from the temperature of the atmosphere, without taking into account the conditions of illuminationas well. In this case the actual amount of heat received by the plant organism under identical temperatures would be higher with longer exposure to sunlight. The actual amount of heat so received in a day might well prove to be higher in latitudes with longer daylight, even where atmospheric temperatures were identical. Thus we might expect a reduction inthe aggregate atmoshperic temperature required for completion of the growing season to maturity, as cotton growing moved northward from latitudes with short days into latitudes with longer days.

Future investigations into this subject will bring firm conclusions and give it a more definite status. It is even today necessary to note as a highly desirable method and calculation of thermal conditions of the development of the cotton plant by immediate measurement of plant temperatures.

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Atmospheric Humidity

A large number of physiological processes in the plant organism are unquestionably influenced by atmospheric humidity, such as transpiration, heating and cooling of the plant tissues, etc., and therefore this factor, during the period of the development of the plant in the field, may be expressed both in its behavior and its productivity. For instance, the excessively dry air of the so-called arid regions, where a number of crops suffer from insufficiency of soil moisture, dry winds, etc., is obviously an unfavorable factor for such regions.

Our comparison of the atmospheric humidity with the rapidity of development and the productivity of cotton under the conditions of the Ukraine nevertheless gives an inverse variation as the rule: drier air; more rapid development and higher yields. However, we have no reason to treat this variation as causal in nature, for atmospheric humidity depends most closely on temperature. As a rule the march of atmospheric humidity repeats the general pattern of the march of temperature, but inversely; the warmer the air, the drier it is. For this reason the above indicated connection with atmospheric humidity may be shown to be in reality merely the result of a causal connection between the rate of development and productivity of cotton on the one hand and the thermal levels on the other. Experimental verification of this is expected from research in the near future.

The inverse connection with humidity shows that its reduction in general does not result in extremely sharp reduction of cotton crops, which in turn indicates the relative stability of cotton yield under atmospheric drought.

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Examining the data for the separate months, our attention is particularly attracted by the high indicia of an inverse relation between atmospheric humidity during August and yield, while we should have expected to find that increased dryness of the air during blooming and boll formation to reduce yield by contributing to the shedding of the ovaries and bolls. The correlation between August relative atmospheric humidity and yield, based on data for 1924 - 1930, is 0.86 ± 0.07; and between the August deficit in humidity and the yield the correlation is 0.93 ± 0.03. This has, however, not yet been verified for the more southerly zones of the new regions, where the dryness of the air is more pronounced. No quantitative expression is yet available for the degree of harmfulness of the dry winds during this crucial period of August in the various zones of the new regions.

Inside the limits of a single group of the driest years, the higher relative humidities during the growing season correspond to the higher yields.

For observations at 1300 hours, the deficity of atmospheric humidity expressed itself in the yield as follows:

	1924	1927	1929
Total Yield	4.5 incomplete	8.8	12.2
Deficity of Atmospheric Humidity from May to October, inclusive	15.0	13.0	13.5

It might thus be thought that sharply expressed dryness of the air, also under Ukrainian conditions, reduces the yield of cotton.

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The literature on cotton growing refers to the retarding effect of extremely low atmospheric humidity on the development of cotton. Thus E. E. Fedorov and A. V. Gedeonov remark, in their Duration of the Phases of Development of the Cotton Plant under Various Types of Weather, that mean humidities under 40 percent "clearly have a tendency to prolong the phases, with the possible exception of the final phase; boll formation and maturation". However there is also some indication in the literature (Moiseyenko, The Quality of Cotton Picked at Various Dates.) that the littoral districts of the new regions (with their higher atmospheric humidity) yield lint of higher grades than these remote from the sea.

It is natural that questions involving more detailed study of the part played by atmospheric humidity in the development and crop formation of cotton as well as other meteorological factors, on lint quality, should attract the attention of research workers. They accordingly have a definite place in the current program of NOVNIKhI.

To recapitulate, there is still no solid reason to consider increased atmospheric humidity harmful for the cotton plant, and increased dryness beneficial. Further than that, extreme dryness of the air can apparently reduce both quality and quantity of the crop. Dryness of the atmosphere is perhaps clearly beneficial only during the period of approaching maturation and that of the opening of the bolls, since it accelerates the mechanical processes of drying and opening of the bolls, reduces the probability of fungus infection of the lint, reduces the moisture content of the lint, etc. This leads to improvement of the quality of the raw cotton and simplifies its storage and utilization.

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The new and old cotton regions may be compared as to atmospheric humidity by taking the available data for mean humidity from April to October in Kherson and Tashkent. In Kherson is is 65.9 percent, compared with 53 percent for Tashkent (L. A. Molchanov, A Contribution to the Question of the division of the Cotton Area into Climatic Regions.). Comparison between other points of the new and old regions give results substantially the same if not more striking. It is evident from this that cotton growing in the old regions is characterized by sharply increased dryness of the air as compared with the new regions, and that, if extreme dryness of the air really has an unfavorable effect on quantity and quality of the cotton crop and hampers the development of the cotton plant, etc., then the new regions will be found to be considerably more free of these unfavorable phenomena.

Winds

Winds play an immense part in agriculture in general, and in cotton growing in particular.

Strong winds immediately before or immediately after the planting season are unquestionably harmful, since they dry out the topsoil and the cotton seed then lies in an insufficiently moist soil layer.

Dry winds in the period of fruit formation are also harmful, especially during the period of the inception of the bolls, as they result in excessive transpiration and insufficient water supply to the above ground parts of the plant.

Boll opening is accelerated, however, where insufficiency of moisture develops only shortly before their normal opening, and in most cases this should be considered a favorable event.

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In the literature [V. D. Novikov, Research into the Assimilative Processes, Dynamics of the Stomatal Apparatus and Transpiration of the Cotton Plant, (1930)] there is also a reference to the closure of the stomatal fissures provoked by strong winds, thereby reducing the level at which assimilative processes function.

Strong winds may also have an unfavorable effect on the quality of the lint by tearing it out of the bolls, soiling it with dust, interfering with picking, etc. Work has just been completed on a classification of the winds according to their degree of harmfulness, as well as a study of their role as it affects the cotton crops in other ways, and therefore we shall not linger here on a further disucssion of their characteristics and significance.

The establishment of connections between the development of the cotton plant and single meteorological elements has still given us no answer to the problem of their influence and joint action on the yield, which is the most important practical question. Its solution should show us what yields may be counted on in a given set of natural (climatic) conditions in a given locality, which information is essential for purposes of planning, etc.

There are still no completely reliable and verified practical methods of calculating the ensemble of climatic influences as a single factor exerting a unified effect, and we must still use indirect methods for evaluating that ensemble. We start with the conditions that the maximum harvest obtained in a given year on the territory of the area to be appraised shall be an index number expressing the totality or resultant of climatic influences for the year, assuming further the highest attained level of agricultural technique.

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The data on the recorded harvests in Kherson, where agricultural methods also include irrigation, sketch the following picture:

YEARS	1925	1926	1927	1928	1929	1930	1931	1932	Mean, Excluding 1932
Yield in Tsentner Per Hectare	2.0	6.5	16.7	6.2	30.0	10.3	26.1	11.6	13.7

We see from this that modern agricultural techniques, including irrigation, are capable of obtaining annual cotton crops in the Kherson area not lower, as a rule, than 6 tsentner per hectare, based on the total harvest, that is, even under unfavorable meteorological conditions as a whole (as in 1926) a yield of 6 tsentner per hectare is entirely attainable. This is apparently contradicted only by the figures for 1925. But in that year the yield from bolls that did not open of themselves was excluded from the total; moreover, the specific agricultural techniques for cotton growing in the new regions, including the Ukra ne, had not yet been worked out, and finally the figures for that year relate to a less early variety (169) than those at present in practical use.

The results from the practice of unirrigated cotton growing are even more convincing. Although these production figures include such times and such years of unfavorable weather as 1930, when there were damaging heavy rains in spring and exceptionally low temperatures in spring, the beginning of summer and in the fall, the better kolkhozes, complying with the rules of cotton agronomy, did not fail even in such a year to obtain a yield of lint higher than 6 tsentner per hectare.

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Thus in 1930 the Perebudova Artel in Golopristanskiy Rayon obtained an average yield of 6.4 tsentner of lint per hectare and the Chervoniy Prapor also obtained the same yield, while similarly situated Kolkhozes that knew nothing of the methods of handling cotton obtained only insignificant yields.

In 1931 yields of 10 - 12 tsentner per hectare were obtained by a number of kolkhozes, and on single farms as much as 16 - 18 tsentner.

In 1932 the highest yields on the best farms reached 8 tsentner per hectare (Obshchiy Trud - Khleborob in Genicheskiy Rayon, Kolkhoz imeni X Godovshchiny Oktyabrya in N. Odesskiy Rayon).

Thus the decisive factor here in obtaining cotton yields is not weather conditions but agricultural technique, the role of which becomes particularly responsible when weather conditions are bad, since with bad management of cotton, crop losses in years with unfavorable combinations of meteorological conditions grow up faster than in favorable years. It is enough to point out that badly organized incrustation control measures in years of excessive May rains can result in the elimination of extensive tracts from the category of plantable acreage.

In cool and humid years, little favorable for cotton, the plants are subject to great danger from the rank development of weeds. In such years failure to observe the rules of cotton agronomy on weed contorl has a particularly pernicious effect on yield.

In cool years, with early onset of frost, all measures of agricultural technique directed at accelerating maturation acquire

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particular importance; area of supply, planting date, etc. The newer methods, such as vernalization, transplantation of seedlings, etc., should also be used, and also the proper varieties. While in years with favorable weather conditions some departure from the rules of agricultural technique may entail only relatively minor reduction in yield, the same departure in unfavorable years may cause tremendous reductions in yield as well as impairment of quality, since every day gained plays a great part in the outcome of the cotton season.

Poor organization of the measures to controlvarious causes of crop loss will also cause sharper drops in the yield if the autumn is cool and windy than if it is dry, calm and warm.

Finally the responsible part played by cultural practices under unfavorable weather conditions is obvious, as is its exceptionally important role in the efforts to improve quality and assure proper picking, drying and storage at the proper time.

CONCLUSIONS

1. Heat is the most important element for cotton in the entire climatic picture, at least in the northern part of the new regions (Ukraine), and therefore, given the same cultural practices, the yield of cotton depends upon it most of all. The more heat the cotton plants receive in any given year, the shorter the time it takes to mature and the higher the yield per hectare, if the basic rules of cultural practice are followed.

2. The correlation noted in cotton literature between the time required for the development of the cotton plant and the temperature levels prove on more detailed analysis to be confiremed only in general.

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In a number of cases, one phase or the other takes longer with a higher temperature, and this may be ascribed in some instances to the retarding effects of the minimum temperatures and the increased dryness of the air, but in other instances it may be due to the retarding effect of high temperatures. To a certain extnet the weather in the new regions does have minimum temperatures low enough to retard the development of cotton plants. The weather in the old regions, on the other hand, frequently show the retarding effects of high maximum temperatures. This partly explains the lack of correspondence observed between the behavior of the cotton plant and the thermal resources of the old and new cotton regions, judged by the mean diurnal temperatures alone.

3. The lack of correspondence not infrequently observed between thermal conditions and the rapidity of development of the cotton plant in its later stages may be explained to a great extent as the result of the temperature after-effect, which appears on analysis of the temperature conditions under which cotton develops in the old and new cotton regions. The phenomenon of the temperature after-effect is apparently of more general occurrence than vernalization, and consists in the reduction of the total temperatures required for the completion of the later stages of development where increased total effective temperatures have been accumulated during the earlier phases, and vice versa.

The isophase of the saboteur Zaytsev, applied to any period of development of the cotton plant without being related in any way to the preceding temperature conditions, must be deemed inapplicable if only because it distorts the actual relationship of the cotton plant to the thermal conditions.

The significance of atmospheric temperature conditions for cotton

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is, moreover, modified by its relation to soil temperature, which must be taken into account in apprais ng any cotton region.

4. Judging by the temperature readings in the meteorological booth, the processes of vernalization of cotton under natural conditions can probably proceed with mean diurnal air temperatures of the order of 18 to 16 degrees. These levels are usually attained during the middle decade of May and more definitely so during the final decade. If sowing is done later than May 15 - 20, therefore, there is usually a marked retardation of budding and of the subsequent phases of development, resulting in both quantitative and qualitative inferiority of the crop.

5. The normal temperature indices over a number of years for the Ukraine c rrespond to an above-average productiveness for cotton, i.e. to a total yield of 6 - 8 tsentner per hectare. Temperature conditions are unsatisfactory in about 16 percent of the growing seasons, but in view of the latest achievements of science, this figure may be considered exaggerated.

6. In view of the observed inverse correlation between temperature and precipitation, it appears difficult to develop the role of precipitation in the formation of the cotton crop on the basis of general statistical evaluation. Under the same temperature conditions higher yields of cotton are obtained in years with higher precipitation during the growing period. In comparing years with the same precipitation during the growing season, we find that higher yields are obtained in years with higher precipitation preceding the sowing period and higher stocks of moisture up to that time. This agrees perfectly with the

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result of the experimental irrigation of cotton in the new cotton regions, in which irrigation at the flush of anthesis, in hot dry years, succeeded in more than doubling the yield.

The cotton plant can, however, reconcile itself to extremely severe soil moisture conditions, and is able to complete its development more or less normally by drawing fully on all available stocks of soil moisture, and even when it receives moisture only in the layers deeper than 80 - 90 centimeters, it still gives an economically useful yield, and meets the requirements of the planned assignments of the national economy in its present stage of development.

For the overwhelming majority of the cotton districts in the new regions, unirrigated cotton growing may therefore be developed as the basic agrotechnical form of its culture.

7. Though cotton belongs to the short-day group of plants, the early varieties cultivated in the new regions react only slightly to a shortened day, and therefore there is no reason to expect noticeable retardation of fruiting to result from the shift from the old regions to more northerly areas with a longer day, while in this case the leaves have an additional opportunity to utilize the thermal energy of sunlight. The temperature of leaves of plants exposed to sunlight can be as much as 4 - 6 degrees higher than that of leaves not so exposed. Insolated leaves may be warmer than the surrounding air by an amount of the order of 2.5 - 3.5 degrees. Finally, leaves so insolated may be 1.5 - 2.0 degrees cooler than the surrounding air during the daytime. This circumstance is very important for cotton, as a warmth-loving plant, since with equal atmospheric temperatures it does in fact receive

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more heat during a longer period of daylight illumination (a longer day).

8. There would seem to be some confirmation of the phase-retardation to which the literature alludes, as a result of exceedingly low atmospheric humidity. Low atmospheric humidity has not, however, been definitely shown to be a factor retarding development, perhaps because very low atmospheric humidity is relatively infrequent in the new regions. Further direct experiment will be required to verify this.

Exceedingly high temperatures and great dryness of the air are characteristic of the old regions to a higher degree than of the new regions.

9. The climatic conditions in the new regions allow total annual lint yields not lower, as a rule, than 5 - 6 tsentner per hectare.

10. In the next plan for winning higher productivity it is essential to give priority to the question of eliminating the spread between the actual yield and the yield that would be assured by the natural conditions in the new regions if the presently available achievements of science were applied.

The path to this is only through the organizational, economic and political strengthening of the cotton sovkhozes and kilkhozes, since only under such conditions will it be possible for them to master perfectly the technique of growing cotton on the northern borders of its cultivation.

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THE ROOT SYSTEM OF COTTON AND CULTURAL PRACTICES

M. T. Taranovskaya

Almost all cultural methods act primarily and immediately on the root system of cotton, and the result of this action is reflected in one way or another in the development of the above-ground portions of the plant.

As the earliest work has shown, the development of the root system of cotton can be regulated to a greater or lesser extent, inasmuch as it is of an extremely plastic nature and reacts sharply to modifications of such factors as soil moisture, area of supply, fertilizers, etc.

In studying the influence of various cultural methods on the development of the root system, the following were investigated in the first place;

1. The dynamics of growth of the root system of cotton.

2. The influence of the area of supply and the form of the plot on the development of that root system.

3. The root system and the location of blooms.

4. Depth of plowing and depth of working in fertilizer in their influence on the development of the root system.

5. Influence of moisture on the various stages of development of the cotton plant, with and without fertilizer.

6. The root system in different varieties.

In studying the root system the author mainly used the method of Kachinskiy.

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DYNAMICS OF DEVELOPMENT OF THE ROOT SYSTEM OF COTTON

The development of the root system of cotton, like that of the plant as a whole, depends on the whole complex of the factors that surround the plant, on the nature of the plant itself, on the variety to which it belongs, and, to some extent, in cases where it is not indigenous, on the degree to which it has become acclimated to our conditions, i. e., whether it has been reproduced locally or has been imported from another locality. Plants react differently to cultural methods according to differences in all of these factors, and we must perforce consider the results obtained by the Ukrainian Zonal Station on the development of root systems as having merely a general significance for orientation only, and assume that deviations in one direction or another are always possible, owing to the above mentioned factors or the meteorological conditions of the particular year in question.

At the beginning of vegetation, the aboveground part of the cotton plant develops rather slowly. All the vital energy of the plant is turned towards the development of its root system.

Before the seed lobe has succeeded in freeing itself from the seed cover, the rootlet has already attained a depth of 10 - 12 centimeters. By the time the first leaflet appears, the root (in 1923) is four times as long as the stalk (height 7.8 centimeters, length of root 30 centimeters).

During the budding phase, the roots are five times as long as the above-ground parts of the cotton plant (height 14 centimeters, root length 74 centimeters).

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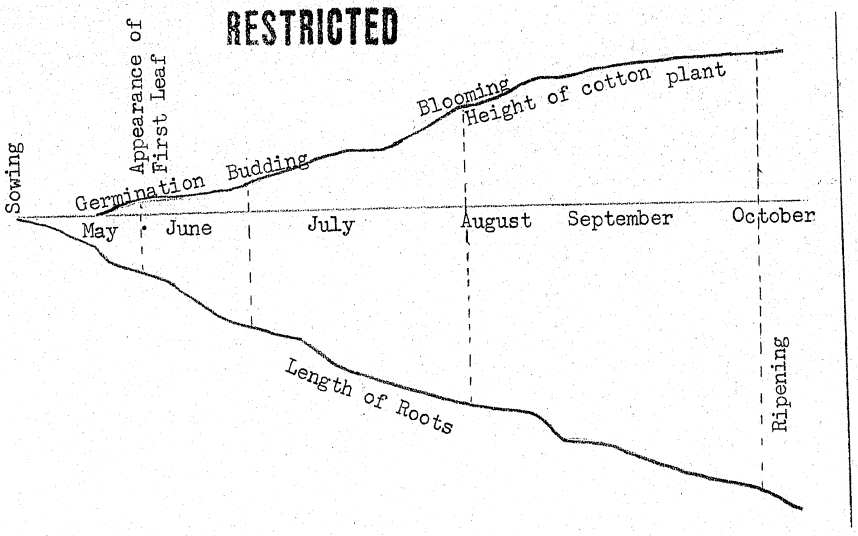

Figure 8. Dynamics of development of the root system and the above-ground parts of the cotton plant (variety Shreder 1306) according to 1932 data.

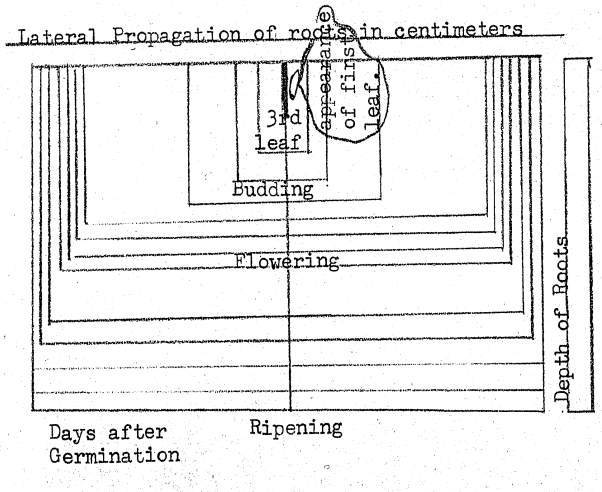

Figure 9. The root system of the cotton plant in the various stages of development.

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During the first 2 - 3 ten day periods in the life of the cotton plant, the average daily growth of the taproot is about 2.5 centimeters.

The lateral roots usually begin to appear at the same time as the first leaf. They were 13 - 15 centimeters long on the 20th day after germination, according to 1932 observation.

A graphic picture of the development of the plant from germination to maturity is given by the diagram in Figure 9.

A month after germination the downward growth of the roots slackens considerably during the budding period, and amounts then to about 1 centimeter per day, and sidewise development of the lateral roots then proceeds more energetically (see diagram), their energetic propagation being mainly in the rich humus horizon and thus obtaining nutrient for the plant.

However, the nutrients in this horizon can only be used by the plant if there is a definite minimum of soil moisture, and when the stocks of the latter diminish, the laterals, which had hitherto been propagating almost horizontally, then begin to go deeper into moister horizons, forming a dense network even in the deeper horizons.

Cotton plants grown in pots of soil taken from different levels; 0 - 15 centimeters, 15 - 30 centimeters, 30 - 45 centimeters, 65- 80 centimeters, and 100 - 115 centimers, developed best in the pots giving the roots nutrient from the plowed horizon. The plants sowed in subsoil were backward both in the commencement of the various phases and in their general development.

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All cultural methods in cotton growing should therefore be directed towards giving the plan an opportunity to utilize the nutrients from the humus horizon, since the earlier the area of feeding roots is shifted to lower soil horizons, the lower the yield will be.

During the flowering stage, when transpiration reaches its maximum, the cotton plant once more energetically propagates its roots downward (figure 1 - 2), taking over new soil regions with moisture stocks as yet unconsumed, and expanding its water supply basin all the time.

Even during the stage of maturation the growth of the roots does not cease. The difference between the development of the root system of cotton and that of the grains is most striking during the flowering period.

In the gramineous plants, the downward growth of the roots usually stops after flowering, while with cotton it still continues quite energetically.

This may apparently be explained by the fact that maturation in the cotton plant proceeds gradually and that even when some of the bolls have already matured and opened, there are still flowers and ovaries on the plant that continue to demand moisture and nutrients from the roots.

THE MAGNITUDE OF THE ROOT SYSTEM IN THE COTTON PLANT

Contrary to the commonly encountered opinion that the root system of the cotton plant is weak, sparse and that it propagates itself only within a one-meter soil horizon; it has been established by the work

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THE MAGNITUDE OF THE ROOT SYSTEM IN THE COTTON PLANT

Contrary to the commonly held opinion that the root system of the cotton plant is weak, sparse and that it propagates itself only within the 1 meter soil horizon, it has been established by the work of the Ukrainian Zonal Station that this system reaches 200 to 250 centimeters and more.

The taproot of the cotton plant sends off first-order laterals, which propagate at first almost horizontally. Second-order roots branch off from them, and third and fourth order roots then ramify from these, so fine and delicate as to be almost imperceptible in earth dug up for observation, and only by washing away the soil through a fine sieve can their approximate quantity be determined.

The cotton plant can propagate its laterals to very great distances if given ample room at planting.

Comparison of the Rotmistrov root coefficients, obtained by multiplying the depth of the vertical roots by the diameter of the area occupied by the laterals, for cotton and other field crops gives the following result:

Crops (1)	Depth of Roots (2)	Diameter of the area of the root system (3)	Root Coefficient (4)
Winter Wheat	116	126	14,616
Winter Rye	130	92	11,960
Barley	110	72	7,920
Spring Wheat	103	104	10,712
Oats	110	94	10,340

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(1)	(2)	(3)	(4)
Proso Millet	105	110	11,550
Corn	113	134	15,342
Cotton	200	280	56,000
Cotton planted in rows 70 centimeters apart	200	130	26,000

The data on the root system of cotton has been taken from the materials of the Ukrainian Zonal Station for cotton grown with an unlimited area of supply under ordinary cultural conditions, while the data on the other plants is according to Rotmistrov.

It is clear from the data presented that cotton utilizes a considerably larger volume of soil than the gramineous plants, and are thus well suited to the arid conditions of the southern steppe belt of the Ukraine, inasmuch as it can obtain sufficient moisture, even where the percentage of usable moisture in the soil is low, by propagating its roots in depth and in bredth [The author has recourse in this case to a comparison between the size of the root systems of plants growing under different circumstances (Odessa, Kherson) in different years, and therefore the conclusion drawn must be considered as merely hypothetical and requiring further factual investigation. Editorial Board of NOVNIKhI.].

THE PROPAGATION OF COTTON ROOTS IN THE SOIL HORIZONS

The root system of the cotton plant (variety 1306), with an area of supply 60 x 5 centimeters, without irrigation, was distributed as follows among the soil layers, according to 1931 data. The figures express percentages.

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Horizons	Deep Roots	Fine Roots	Entire Root System
A 1 0 - 20	65.5	22.1	42.4
A 2 20 - 30	9.6	6.7	8.0
B 1 30 - 50	10.2	14.1	12.2
C 1 50 - 100	10.9	34.7	23.6
C 2 100 - 200	3.8	22.5	13.8
0 - 200	100	100	100

This should be compared with the distribution of the roots of the gramineous plants among the soil horizons, which was as follows:

Horizons	Root Mass of Oats in Percent[1]	Horizons	Root mass of Spring Wheat[2]
0 - 20	57	A 1 0 - 15	60
20 - 40	20	A 2 15-55	17
40 - 60	9	B 1 55 - 85	20
60 - 80	6	B 2 85 - 120	3
80 - 100	5	-----	--
100 - 120	3	-----	--

[1] According to data of Yu. Sokolovskiy of the Poltava Experiment Station.

[2] According to data of N. Pushkareva in 1925, at the Rostov-Nakhichevan Experiment Station.

It should be noted that cotton makes more uniform use of all soil horizons and that a considerable part of the roots are propagated at levels below one meter. This makes it very drought resistant.

This distribution is subject to sharp changes, however, depending

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on other factors, of which moisture and nutrients are the basic ones.

THE INFLUENCE OF CULTURAL METHODS ON THE DEVELOPMENT OF THE COTTON ROOT SYSTEM

The dynamics of development of the root system of cotton also depends, in its various phases, on cultural methods; the depth of plowed soil beneath the cotton plant, the depth to which fertilizer is worked in, etc.

The opinion has been expressed that the medium in which the roots of a plant grow, whether it be water, sand, light loam or heavy clay, does not exert a decisive influence on the development of the form of the root system (V. I. Rotmistrov. The Root System in Cultivated Plants, 1927. pp. 24 - 25).

The results of a two year study of the development of the root system of cotton under varied cultural methods indicates its extraordinary plasticity and that its form is a means of propagation through various soil horizons, depending on sharply differeing conditions.

The form of root system of cotton is very plastic, as may be seen from the photographs in Figures 10, 11 and 12.

As we see, with a turnover of the fallow soil to a depth of 40 centimeters and introduction of fertilizer to an equal depth, the principal mass of rootlets was distributed at this depth. Rootlets were considerably less frequent in the upper horizon of the soil, which is slightly less fertile when so tilled (Figure 11).

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On introduction of fertilizer to a depth of 40 centimeters, without turnover of the soil, two belts were formed, the first in the humus layer and the second along the line of the fertilizer. (Figure 12).

During further investigations on the development of the root system, the opinion that the size of the above-ground part is directly proportional to the size of the underground part of the plant was not confirmed, since in cases where the soil contained sufficient moisture and nutrients a root system with only a small weight can yield a large above-ground mass.

Figure 10. Propagation of the root system of cotton with ordinary tillage.

Figure 11. Propagation of the root system of cotton with turnover of the soil to a depth of 40 centimeters and introduction of mineral fertilizers at the same depth.

Figure 12. Propagation of the root system of cotton with ordinary tillage, but with introduction of mineral fertilizer at the depth of 40 centimeters.

It is also inaccurate to deny the influence of plow depth on development of the plant; V. Rotmistrov draws the following conclusions in his pamphlet The Root System:

1. "If the root system of our cereal and tilled plants goes as deep as 1 meter, and beyond, then the pulverization of the soil to 10, 15 or 20 centimeters will help the roots just as little to go deeper into the soil, and 10 - 20 centimeters is only an insignificant part of the total root length of 100 - 200 centimeters."

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2. "Within a few days after germination, the tips of the roots go behond the bounds of the tilled or plowed horizon (15 centimeters). Both these facts indicate that the depth of plowing is unimportant for mellow soils, -sandy loam, light loam.".

When the demonstrated activities of the root systems in the absorption of nutrients from the soil horizons are compared, the error of these considerations becomes apparent.

The basic error of this assertion is in that the root system, once it arrives at the limits of the plowed horizon, does not leave that layer and continues to draw its nutrients from there during almost the entire growing season, in exactly the same way, since the lower horizons are relatively poorer in nutrients, and if the plant is compelled to place its roots exclusively at those levels, its development will be very weak and its phases greatly retarded.

In 1932 a special experiment was undertaken with soil columns moved without disturbing their structure. Observations were made on the exposed profile of soil horizons.

In early spring a soil column with undisturbed structure, 1.5 meter deep, 100 centimeters long and 6 centimeters thick, was placed in a specially prepared cell. This column was buried in the earth in such a way that on the surface a narrow strip of the side remained open, with the various horizons visible.

On May 2 cotton plants were sown here at a distance of 5 centimeters apart. Sprouts appeared within a few days. The further development of the plants was unequal. The plants sown in the humus

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horizon developed normally, while those sown in the subsoil were stunted and developed feebly. In October the column was dug out, and the roots washed off. It appeared that those plants which had been forced to nourish themselves exclusively on the lower horizons had been unable to develop normally.

Although the root system of cotton descends more or less evenly to a great depth, traversing all the soil, the value of the different soil horizons for plants is not the same.

The root system goes deep into the soil in search of moisture, occupying larger and larger volumes of soil, but soil nutrients are mostly gathered by the roots that have propagated not far from the surface.

It is in this location that the biochemical processes of the soil proceed most energetically of all (which can be seen, though only in the energy of intensification); here too, near the surface, the roots can obtain oxygen and better temperature conditions.

The nutrients available at a depth of 40 centimeters were not utilized, and the plants starved and were stunted. The behavior of these plants was the same as that of cotton grown on subsoil.

The results of investigation into the levels from which the cotton plant takes its nutrients give reason to believe that the function of roots propagated through the deep horizons of the subsoil is principally that of obtaining water for the plant.

It may be assumed that roots with different functions would also have different chemical compositions, and this is confirmed by

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analysis. The nitrogen content of cotton roots was as follows, in percent:

Depth	0 - 50 centimeters	50 - 100 centimeters
Thick Roots	1.96	1.34
Thin Roots	2.00	1.44

Roots taken from deep soil layers are considereably poorer in nitrogen than those from the upper regions. This also gives some reason to assume that with respect to nutrition the principle part is played by the upper soil horizons and the root system propagated through them.

To elucidate this question we made the following experiment. A number of soil columns with undamaged structure, 150 x 100 x 5 centimeters in dimension, were taken out in the spring. Some of them were buried in the ground with the normal arrangement of their horizons, while some were inverted so as to place the humus horizon on the bottom and the loess horizon on the top. In November, when the bolls had already opened on the cotton plants in the normal columns, the cotton plants in the inverted columns were only budding. The columns were then dug up and washed out.

It now appeared that the roots in the column with the humus horizon on the bottom had reached that horizon, and developed a fairly dense network there, but that they had not utilized the nutrients at that level, so far below the surface, as soil analysis showed.

The cotton plants did not develop normally under these conditions and remained in the budding phase until almost the end of the growing season, reaching a height of 14 centimeters, while in the normal column the height reached 56 centimeters and gave the same yield ob-

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tained under field conditions. Thus the depth to which the plant had to go for its nutrients determined the yield in this experiment as well.

The humus horizon is very important for the development of the plants, and therefore the depth to which that horizon is plowed, which conditions the water, air and nutrient regimen of the soil, is of great significance. This is as also confirmed by the results of another experiment on this question which was carried out in the laboratory section in 1932.

The object of the experiment was to ascertain the extent to which the cotton plant and its root system react to the depth of plowing and to the varying depth of working in fertilizer, in other words, at the depth of the fertile horizon, to find the optimum relation of the factors to enable the root system to supply the plant with the optimum amount of water and nutrients.

There is adirect connection between this experiment and the solution of the questions of depth of plowing and methods of introducing fertilizer under the plants, which are important questions in cotton growing.

Starting from the consideration that the richest upper soil horizon usually dires out very much during the course of the growing season and thus is only lightly utilized by the root system, it was attempted by tilling the soil and turning over the sod, to depress the level of the humus horizon to a certain depth, so that drying out could be reduced and it could be better utilized by the cotton plant.

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Depths of 5, 10, 15, 20 and 40 centimeters were used in the experiment.

The tillage of the soil to the corresponding depths was performed on April 5, 1932.

We shall not now dwell in detail on the results, the observations on the water and nutrient regimes of the soil in their relation to the depth of plowing, on the time of inception of the phases of development in their dependence on the depth of tillage and the depth of working in fertilizer, and can only remark that the tendency of the cotton plant to delay its phases when its nutrients are located at considerable depths below the surface - which tendency we had noted during the experiments on soil columns with undisturbed structure - was fully confirmed by these field experiments on laboratory plots. It was most clearly reflected in the case of the plowing to 40 centimeters with sod turnover, with fertilizer already introduced at the line of the humus horizon. In this case the budding phase was retarded by 4 days and the flowering phase by 13 days. While only 20 percent of the bolls had opened on these plots by the end of the growing season.

With deep plowing and sod turnover, with fertilizer in the upper horizon, and also on the plots with tillage to 40 centimeters without sod turnover, no retardation on the onset of the phases was observed.

Even though the root system of cotton plant goes down to 2 meters and deeper, and the 10 - 20 centimeters of the upper horizon is "only an insignificant part" in relation to that volume of soil through which the root system is propagated, this "insignificant part"

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can nevertheless determine the size of the cotton crop.

THE INFLUENCE OF DEPTH OF SOIL TILLAGE ON THE DEVELOPMENT OF THE ROOT SYSTEM OF THE COTTON PLANT

The computation of the weight of the roots made during the latter half of August included both small roots fand main roots (the skeleton of the root system) and revealed a considerable difference in the scope of development and the method of propagation in the various soil horizons, depending on the depth of tillage and the depth of working in of the fertilizer.

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WEIGHT OF SMALL ROOTS IN DIFFERENT SOIL LAYERS ACCORDING TO DEPTH OF PLOWING

Depth of Tillage	Depth of Layer in Centimeters										Weight of Roots	
	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	0 - 100	in Kilograms per hectare
Tillage to 10 Centimeters	1.00	0.60	0.45	0.68	0.96	1.04	0.86	0.96	0.52	0.51	8.48	353.6
Tillage to 15 Centimeters	1.05	0.79	0.55	0.53	0.82	1.20	0.63	0.82	0.56	0.28	7.88	326.5
Tillage to 20 Centimeters	0.63	0.80	0.50	0.49	0.68	0.91	0.68	0.51	0.27	0.23	6.80	283.6
Tillage to 30 Centimeters	0.33	0.57	0.68	0.78	0.65	0.61	0.60	0.52	0.56	0.45	7.45	310.7
Tillage to 40 Centimeters	0.27	0.40	0.65	0.94	1.20	0.95	0.90	0.84	0.60	0.47	8.42	351.1
Tillage to 40 Centimeters without Turnover	0.98	0.88	0.76	0.71	0.83	0.64	0.55	0.44	0.34	0.28	6.88	286.9

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WEIGHT OF LARGE ROOTS IN DIFFERENT SOIL LAYERS

Depth of Tillage	Depth of Layer in Centimeters										Mean depth 100 - 200 centimeters	Total weight in 2400 square centimeters	Total in kilograms per hectare
	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100			
Tillage to 5 Centimeters	10.22	1.85	1.00	0.89	0.70	0.71	0.32	0.16	0.16	0.17	0.04	17.12	713.9
Tillage to 10 Centimeters	9.89	2.00	1.31	0.88	0.75	0.58	0.65	0.52	0.34	0.18	0.09	18.00	750.6
Tillage to 15 Centimeters	8.91	2.67	1.14	0.77	0.69	0.86	0.80	0.38	0.24	0.15	0.03	16.91	705.1
Tillage to 20 Centimeters	9.12	2.94	0.99	0.60	0.60	0.35	0.50	0.19	0.30	0.17	0.06	16.36	682.2
Tillage to 30 Centimeters	7.54	2.47	1.96	0.86	0.59	0.40	0.37	0.26	0.24	0.16	0.09	15.75	656.8
Tillage to 40 Centimeters	7.39	2.00	2.08	2.65	0.81	0.76	0.45	0.41	0.32	0.27	0.05	15.64	650.9
Tillage to 40 Centimeters without turnover	10.45	1.13	0.98	0.90	0.56	0.55	0.22	0.19	0.05	0.08	0.05	15.61	650.9

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Analysis of the data in the above tables shows that the greatest quantity of roots is found in the upper horizons along the lines of the occurrence of the humus layer or along the lines of introduction of fertilizer. With plowing down to 80 centimeters, the small roots proceed through the compressed horizon and form, as it were, a second belt, in which apparently the plant takes water when the plowed horizon dries out.

With plowing to 40 centimeters, with sod turnover, there is only a single belt of roots; the active zone of roots is then located at the 40 - 60 centimeter level, and there are considerably fewer small roots in the upper horizon when such plowing is done. This lack of small roots is due, in this case, to the fact that the upper horizon proves to be less fertile when plowing is too deep. With such plowing the humus layer lies at a depth of 40 centimeters, and therefore the greatest distribution of roots is just in that horizon. But the conditions for biochemical processes are less favorable at such a depth. The same must be said of temperature conditions and the air regimen of the soil.

Under conditions of "normal" tillage, when the humus horizon (18 - 20 centimeters on chestnut soils) does not cover the top of the subsoil, a dense little network of roots usually develops in the upper horizon when moisture conditions permit. As the moisture supply in the upper horizons decreases, the network of feeding roots spreads out lower, where there is more moisture. The roots leave the plowed horizon only after conducting a careful search in a horizontal direction for moisture and nutrients. They find more moisture but less nutrient in

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the depths. As soon as the moisture increases on the upper horizons, new young roots appear on the first and second order roots. But this stratum on the upper horizon is regenerated only in "cultured" soil, when favorable conditions are created for the accumulation of nutrients as well as moisture, aeration, etc. When this is not the case, then, as has been vividly shown by the experiment on the artificial displacement of the humus horizon by one less fertile, the yield of lint declines.

The development of the root system undergoes even more decided change when the fertility of the different horizons is changed by turning over the surface layer and applying fertilizer at the corresponding depth (at the bottom of the furrow). In that case the weight of the roots on the respective horizons is distributed thus:

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WEIGHT OF SMALL ROOTS ON DIFFERENT SOIL HORIZONS WITH INTRODUCTION OF FERTILIZER AT DIFFERENT DEPTHS

Depth of Fertilizer	Weight of Roots at Levels										Weight of Roots between 0 - 200 centimeters in grams per sample	Weight of roots between 0 - 200 centimeters in kilograms per hectare
	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100		
Fertilizer at 5 Centimeter level	0.89	1.24	0.74	0.65	0.70	0.82	0.85	0.85	0.66	0.39	9.09	379.1
Fertilizer at 10 Centimeter level	1.19	1.01	0.55	0.76	0.64	1.08	0.93	0.71	0.61	0.35	9.33	389.1
Fertilizer at 20 Centimeter level	0.76	0.80	0.65	0.80	0.71	0.83	0.77	0.40	0.24	0.20	7.56	315.3
Fertilizer at 40 Centimeter level	0.35	0.25	0.28	1.00	0.56	0.41	0.36	0.40	0.32	0.37	5.40	225.2
Fertilizer at 2.5 centimeter level, with tillage and turnover to 40 centimeters	1.82	0.35	0.52	0.90	0.89	0.63	0.59	0.59	0.51	0.23	7.03	293.2

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WEIGHT OF LARGE ROOTS AT DIFFERENT SOIL HORIZONS WITH INTRODUCTION OF FERTILIZER AT DIFFERENT LEVELS

Depth of Fertilizer	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 200	Total Weight 0 - 200	Total Weight 0 - 200 kilograms per hectare
Fertilizer at 5 centimeter level	10.68	2.89	0.92	0.61	0.63	0.40	0.33	0.81	0.25	0.13	0.04	17.45	727.7
Fertilizer at 10 centimeter level	11.37	1.67	1.09	0.91	0.67	0.55	0.43	0.26	0.16	0.10	0.04	17.5	730.2
Fertilizer at 20 centimeter level	9.79	2.05	0.72	0.51	0.26	0.20	0.17	0.13	0.10	0.08	0.09	14.91	621.8
Fertilizer at 40 centimeter level	3.25	0.89	1.43	1.80	0.72	0.45	0.10	0.14	0.14	0.12	0.04	9.44	393.6
Fertilizer at 2.5 centimeter level, with tillage and turnover to 40 centimeters	10.77	2.14	0.95	0.64	0.64	0.34	0.24	0.28	0.13	0.13	0.07	16.93	706.0

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The root system is most developed on the horizon that has most nutrients. Though nitrogen as nitrate can readily travel in the soil when there is rain, and also have the ability to follow the action of evaporating water, the roots are, nevertheless, mainly distributed in the horizon where the fertilizer was introduced, i. e., they follow the fertilizer.

The difference in the depth of the fertile horizon was reflected in the distribution of the thick roots, resulting in the most extensive development in the fertile horizon. All of this agrees with the observations of the same nature at the Rothamstead Experiment Station in England, where the roots were noted in all cases to be in contact with the fertilized horizon, where they were not more densely developed and more widely ramified, but also plainly held back by that layer from travelling on to lower horizons.

THE DISTRIBUTION OF ROOTS IN THE SOIL PROFILE WITH DIFFERENT PLOWING DEPTHS.

Observation on the distribution of root systems in the soil by the method of cubics /The method of cubics was developed by Comrade Taranovskaya./ makes it possible to learn not only the total quantity of root material in each horizon but also the density of the root system at different distances from the plant. This has shown that when the rows are spaced as closely as 5 - 10 centimeters the root system of the cotton plant develops in most cases on both sides, and that almost all the laterals spread into the spaces between the rows, running almost horizontally to the middle of these spaces and then turning sharply downward.

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In general the roots of the cotton plant are uniformly distributed through the soil, which makes it possible for them to utilize completely the stocks of moisture and nutrients, but their distribution does vary with the depth of plowing.

The space between the rows is most fully utilized by the roots when the root system is distributed through normally tilled soil, and veryfew roots are distributed through the upper levels of that space when tillage is to 40 centimeters, with turnover. Under the latter conditions, the "center of gravity" of the root system lies considerably lower, with consequent and already noted unfavorable effect on the yield of the cotton plant.

Cotton seedlings are very sensitive to the concentration of soil solutions. The method of introducing fertilizer at random is disadvantageous for the development of the roots, even though the depth may be proper. However deeply fertilizer may be introduced, even down to 40 centimeters, the roots of the cotton plant descend rapidly and reach it by the 17th day after germination. A concentrated solution of mineral salts unfavorably influences the utilization of moisture by the plant, since under such conditions the access of water is rendered most difficult.

Special attention must be paid to the local introduction of fertilizer at a definite distance from the rows if the early stages of development are not to be unfavorably affected by this increased concentration of the soil solutions, especially in arid years.

The roots of the cotton plant are rather uniformly distributed through the soil, which makes it possible for it to fully utilize moisture and nutrient stocks; while distribution of the roots varies according to depth of plowing.

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WEIGHT OF COTTON ROOTS IN THE SOIL LAYER 0 - 200 CENTIMETERS AND THE DEPTH OF TILLAGE

Depth of Plowing	Weight of Roots in Kilograms per hectare			Yield of Lint in tsentner per hectare	Weight of Above-ground mass in tsentner per hectare	Root weight in percent of above-ground weight
	Large Roots	Small Roots	Total			
Plowing to 5 Centimeters	7.33	3.85	11.18	---	---	---
Plowing to 10 Centimeters	7.31	3.28	10.59	12.40	28.40	37.3
Plowing to 15 Centimeters	7.06	2.84	9.90	12.92	29.60	33.4
Plowing to 20 Centimeters	6.84	2.82	9.66	13.06	29.75	32.5
Plowing to 40 Centimeters	6.28	3.09	9.37	9.19	22.47	41.7
Tillage to 40 Centimeters without turnover	6.91	2.79	9.70	12.12	29.12	33.3

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WEIGHT OF ROOTS IN SOIL LAYER 0 - 200 CENTIMETERS, WITH FERTILIZER INTRODUCED AT DIFFERENT DEPTHS

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Depth of Working in Fertilizer	Weight of Roots in Kilograms per hectare			Yield of Lint in Tsentner per Hectare	Weight of Above-ground mass in tsentner per hectare	Root weight in percent of Above-ground weight
	Large Roots	Small Roots	Total			
Fertilizer applied to depth of 5 centimeters	7.29	3.72	11.01	13.57	29.63	37.2
Fertilizer applied to depth of 10 centimeters	7.42	3.79	11.21	13.68	31.96	35.1
Fertilizer applied to depth of 20 centimeters	6.28	3.06	9.44	14.13	32.33	29.2
Fertilizer applied to depth of 40 centimeters	4.17	2.25	6.42	11.69	24.48	26.2
Fertilizer applied to depth of 2.5 centimeters	7.06	3.34	10.20	13.22	32.26	32.2

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The total root weight for all horizons of the two- meter layer varies from 6.42 to 11.21 tsentner per hectare, according to the depth of the fertile horizon. The most favorable combination of factors for the development and functioning of the root system was created by soil tillage to 20 centimeters.

When plowing went down too deep, to 40 centimeters, with turnover, and the root system was forced from the first days of its development into unfavorable nutritional conditions, the yield of the cotton plant was reduced in spite of a great expenditure of plastic material on root system development (the weight of the roots in this case was 41.7 percent of the above-ground parts).

If conditions around the root system are so unfavorable as to disturb its physiological functions, its development will be slow and feeble, and the plant will be backward, so that it cannot give a normal yield. This is the picture observed with plowing and turnover.

All this goes to show that the root system is extremely sensitive to changes in external conditions.

The depth of plowing is sharply reflected in the yield.

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YIELD OF LINT AS DEPENDING ON DEPTH OF PLOWING
(in tsentner per hectare)

Depth of Tillage	HARVEST			
	First Picking, October 10	Second Picking November 1	Third Picking November 5	Total
Tillage to 10 centimeters	6.82	3.02	2.56	12.4
Tillage to 15 centimeters	7.22	2.23	3.47	12.92
Tillage to 20 centimeters	5.28	2.82	4.97	13.06
Tillage to 30 centimeters	1.44	3.78	4.82	9.04
Tillage to 40 centimeters	3.19	2.49	3.61	9.19
Tillage to 40 centimeters without turnover	3.89	3.30	4.93	12.12

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YIELD OF LINT ACCORDING TO DEPTH OF FERTILIZER APPLICATION IN TSENTNER PER HECTARE

Depth of Fertilizer Application	HARVEST: First Picking October 10	Second Picking November 1	Third Picking November 5	Total	Change in yield, in tsentner per Hectare
Fertilizer worked in at 5 centimeters	9.58	2.40	1.59	13.57	---
Fertilizer worked in at 10 centimeters	9.82	2.34	1.52	13.68	+0.11
Fertilizer worked in at 20 centimeters	6.41	2.14	3.58	14.13	+0.56
Fertilizer worked in at 40 centimeters	---	2.12	9.48	11,60	-1.97
Fertilizer worked in at 2.5 and tilled down to 40 centimeters	9.46	2.22	1.54	13.22	-0.35

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This data shows that the maximum yield was obtained with plowed depth of 20 centimeters, and that yield of lint was reduced when tillage was only to centimeters deep.

Plowing to a depth of 30 - 40 centimeters with turnover of the surface reduces the total yield of lint to 9.5 tsentner per hectare, a substantial part of which was represented by linters, but when fertilizer was applied to the upper layer of the plots, their yield improved to levels among the highest. On fields badly overgrown with weeds, where deep plowing is one of the most important methods of weed control, application of fertilizer can completely eliminate the retardation of phases in the growth of the cotton plant which is observed when the humus layer is depressed to considerable depths below the surface.

The greatest total lint yield under 1932 conditions was obtained with fertilizer applied at the 20 centimeter level. But the plots with fertilizer applied at the 10 centimeter level gave the highest yield at the first picking. The 15 centimeter level was not included in this experiment.

When fertilizer was applied at the 40 centimeter level, there was no harvest at all up to October 10, as not a single boll had opened on this plot during the entire period.

Even as late as November 5, when all the cotton plants involved in the experiment were picked, bolls had opened on only 23 percent of the number of plants on these plots.

On the basis of these data, the following conclusions may be drawn:

Varying depth of plowing, which results in marked change in

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root system development, also affects to a considerable degree the development of the above-ground part of the cotton plant and the yield of lint. The depth of the fertile horizon and of the fertilizer application play the major roles in this connection.

The cotton plant develops well when the fertile horizon (the humus layer of the soil, when plowed and turned over, or the fertilized layer) lies no lower than 20 centimeters.

A root system is most efficient when its active zone is located at a depth of 10-15 centimeters below the surface, if the field is completely free of weeds and soil moisture is carefully maintained throughout the planting period.

With plowing down to 20 centimeters and turnover, the quantity of the first picking is somewhat less than with a plowing depth of only 15 centimeters, since the former depth brings parts of the less fertile horizon A2 to the surface. It must be assumed that plowing down to the boundary between horizons A1 and A2, at 18 centimeters, would give optimum conditions for the cotton plant development.

With excessive plowing depth and turnover (40 centimeters), the "center of gravity" of the root system is found at a considerable depth, where the unfavorable water regimen and the inferior temperature conditions prevent biochemicalprocesses from taking place with sufficient energy.

Such plowing and turnover, therefore, whileit has a positive effect during the first stages of cotton plant development, so long as the earth has not yet become packed, affects its further development

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negatively and considerably retards the onset of the various phases.

Deep plowing and turnover does not exert an unfavorable influence in the sense of retarding the phases if fertilizer is applied in the upper horizon after the plowing.

Depression of the fertile horizon to the 40 centimeter level by plowing and turnover, followed by introduction of fertilizer at that level, modifies the ordinary pattern of root distribution even more, resulting in extremely feeble root development on the upper horizon and more vigorous development along the line of the fertilizer. This has a marked effect on the yield, since the bolls had opened before the end of the growing season on only 23 percent of the plants in these plots, and the total yield (including linters) was 15 percent less than that of the control, with extremely poor lint quality, as most of it consisted of linters.

The results of the experimental data of the study of the effects of deep plowing on the cotton plant under the conditions of the Kherson region are in complete contradiction to the conclusions reached by the experimental irrigational station in the former Golodnosteppe (Okrug ?), where deep plowing to 40 centimeters, with turnover, resulting in increasing cotton yields up to 40 percent over those obtained with plowing to 10 centimeters.

Besides this, as that author notes, deep plowing and turnover accelerates maturation by approximately 20 days (Ye. Petrov).

Once again this difference emphasizes that the efficiency of any method must of necessity be tested under the same conditions, natural

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and historical, in which that method must actually be employed.

THE INFLUENCE OF THE AREA OF SUPPLY AND ITS SHAPE ON THE DEVELOPMENT OF THE COTTON ROOT SYSTEM

The distribution of the root system in the soil horizons changes not only with depth of plowing and depth of working in fertilizer, but also depends to a considerable degree on the area of supply and the shape of that area. The data of the investigation (cf tables) show that the weight of cotton roots varies with the area of supply, and that reduction occurs in the aboveground parts and in fruiting as soon as less moisture, nutrient, etc. become available for the plant under such circumstances. It is observed, however, that when the area of supply is reduced, and the struggle for moisture and nutrients increases, the capacity of the root system for work is considerably increased, and if planting is dense, the root masses come to weigh more than the aboveground parts.

[For table see page 140]

If we calculate the yield not per plant but per unit area there is a striking change in the picutre; the maximum yield is obtained in the plots with the smallest area of supply.

Sowing the plants closer together in rows without reducing the distance between the rows has no adverse effect on the distribution of the root system. The growth of the roots on two sides is sufficient to assure the normal working capacity of the root system (Figure 14).

[For table see page 141]

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INFLUENCE OF THE AREA OF SUPPLY ON THE DEVELOPMENT OF THE ROOT SYSTEM OF THE COTTON PLANT (VARIETY 1306)

Area of Supply	Weight of Aboveground masses in kilograms per 100 plants	Weight of roots in kilograms per 100 plants	Weight of Aboveground masses in tsentner per hectare	Weight of roots in tsentner per hectare	Weight of roots in percent of Aboveground masses
60 x 40	5.62	1.59	23.4	6.2	27.5
60 x 20	5.16	1.11	43.0	9.3	21.6
60 x 5	2.24	0.40	74.6	11.8	15.8

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INFLUENCE OF THE SHAPE OF THE AREA OF SUPPLY ON THE DEVELOPMENT OF THE ROOT SYSTEM AND YIELD OF THE COTTON PLANT

Area of Supply	Shape of the area for each plant	Weight of roots in kilograms per hectare			Yield of aboveground mass		Weight of roots in percent of aboveground mass
		Large roots	Small roots	Total	In kilograms per 100 plants	In tsentner per hectare	
300	60 x 5	7.01	3.28	10.28	15.2	50.67	20.3
300	17x 17	7.97	4.04	21.01	9.8	32.50	34.0
600	60 x 10	5.97	2.72	8.69	25.0	41.60	20.9
600	25 x 24	5.16	13.87	9.03	17.2	28.60	31.61
1,600	120 x 5	5.64	3.33	8.97	26.2	43.20	33.2
1,200	60 x 20	4.39	2.51	6.90	38.0	31.63	21.8
1,200	35 x 34	4.94	3.50	8.44	32.0	26.63	32.7

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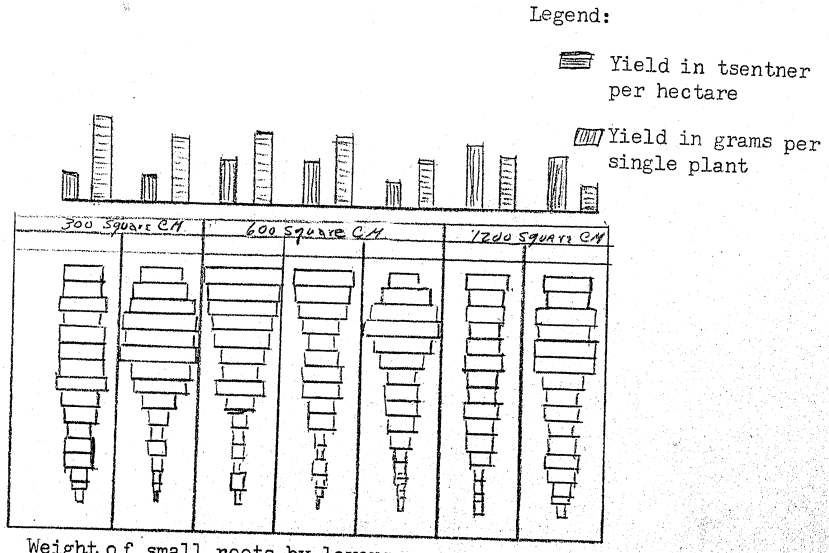
The shape of the area of supply strongly affects the development of the root system and of the above-ground mass of the cotton plant.

The best yield is obtained from an elongated area of supply. Planting in squares reduces the yield, especially where the area of supply is small (300 - 600 square centimeters per plant). This is explained by the longer period that the roots can tap the humus horizon where the area of supply is elongated.

We have already remarked that the root system of the cotton plant is able to stretch out its roots very far so long as they remain near the surface. They travel almost horizontally. In one of the experiments cotton was planted with a space of 120 centimeters between furrows, and it fully utilized even this wide space (Figure 15)



Weight of small roots by layers.

Figure 14. Yield of Overground mass of cotton plant as related to development of root system with different sizes and shapes of the area of supply.

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In studying the root system of the cotton plant, it is almost always observed that the roots, after arriving at the center of the space between the rows turns downward to horizons with still untapped moisture. This downturn occurs earlier when the area of supply is square than when it is the same size but elongated in shape. In the latter case the roots tap the humus horizon for a longer time.

On square areas of supply cotton grows well at first, and spreads its roots out in all directions but the laterals of two adjoining rows meet earlier (Figure 16) than where the area of supply is elongated. When this happens, the roots leave the humus horizon for less fertile layers.

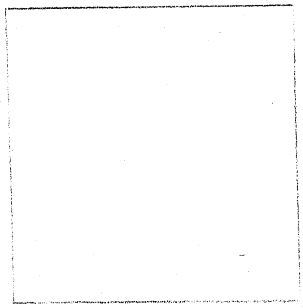

Figure 15. Distribution of the root system of the cotton plant when grown close together in rows. The roots spread out into the spaces between the rows.

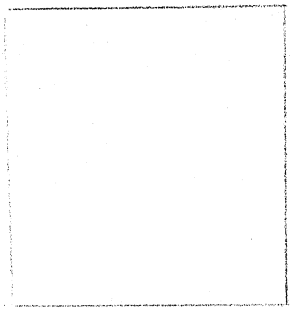

Figure 16. Distribution of the root system of the cotton plant when area of supply is square. The roots soon meet each other and then turn downward.

THE INFLUENCE OF MOISTURE ON THE DEVELOPMENT OF THE ROOT SYSTEM OF THE COTTON PLANT

It has been shown by the experiments of the Ukrainian Zonal Station that yield varies with varying soil moisture, changed by irrigation during various stages of development of the cotton plant.

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The same amount of moisture gives varying effects according to the time of irrigation.

Very slight increases of soil moisture productivity were resulted from increasing soil moisture during the early stages of development, and in some years it even reduced the yield. Irrigation during the flowering phase gave favorable results.

Study of the influence of the time of irrigation showed that during the first stages of development it made the root system less drought resistant. When the upper horizons had a good deal of moisture and the lower horizons were poorer in this respect, the root system did not descend so actively in the soil. When the weather became hot and dry and the upper horizon dried out, the plants with increased moisture requirements now found themselves considerably worse off than the unirrigated plants.

Irrigation during the period from budding to flowering had the most favorable effect on the yield. Irrigation at this time is more effective also by virtue of the fact that it gives the plant an opportunity to use the nutrients in the humus horizon, which usually dries out very much towards the flowering season, under our conditions. The plant receives nutrients during a critical period and expends less plastic material on spreading out its roots through the deeper horizons, where it is necessary to range an immense volume of soil to get the necessary amount of moisture, thus almost doubling the weight of its roots between flowering and maturation. The root coefficient of the cotton plant is considerably greater than that of other plants. but it is very subject to change according to conditions.

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Water Regime	Yield of lint in tsentner per hectare	Dry mass - lint in tsentner per hectare	Weight of roots in tsentner per hectare	Weight of roots in percent of aboveground mass
Without irrigation	13.32	23.64	10.56	44.7
Irrigation during the flowering phase	15.04	34.41	8.64	25.10

With irrigation during the flowering phase, the weight of the roots was 25 percent that of the aboveground mass, while without irrigation, which tends to increase the yield of the aboveground mass as a whole, and of lint in particular, it was 44.7 percent.

Thus irrigation during the early stages of development, under the conditions of the new cotton regions of the Ukraine, makes the cotton plant less drought resistant. Irrigation during the period from budding to flowering enables the plant to expend less plastic material on the underground mass and increases yield by supplying moisture and assuring better nutrition during a critical period.

The effectiveness of fertilizer varies sharply with the time of irrigation. The maximum effect is obtained by two irrigations during the flowering stage (0-0-2-0) or by one irrigation during the budding stage and another during the flowering stage (0-1-1-0). In the former case irrigation without fertilizer gave increased yield of 26 percent over the control (also without fertilizer), while application of fertilizer raises the increase from irrigation to 42.3 percent.

Study of the root system revealed striking differences between the quantity and method of root distribution on the different horizons.

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Irrigation and fertilizer shifted the active zone of the roots to the upper horizons. The plant was supplied with moisture and nutrients during a period critical in these respects. The total absorbent sufacr of the roots increased. The weight of the small roots grew, but the ratio of total root weight to total weight fell, which indicates the greater productivity with fertilizer;

/For table see page 147

When fertilizer is applied and the nutrient position thus improved, the plant might be expected not to develop its root system with the same vigor, since even a relatively smaller absorptive surface could assure its nutrient supply. However, it displayed increased moisture requirements when fertilizer was applied. Even when it was given a single irrigation during the flowering phase, it was still forced to extend its root system vigorously in quest of water. This complex situation leads to the result that when fertilizer is used an increase in the absolute weight of the roots over that in the unfertilized plots is often observed, although the ratio between root weight and aboveground weight is lower than without fertilizer.

THE ROOT SYSTEM IN THE DIFFERENT VARIETIES OF COTTON

A study of the root system in differnt varieties of grains led A. P. Modestov to the conclusion that the rooms are longer, the later maturing the plant happens to be.

In studying two varieties of cotton, the early 1306 and the later "Triumf Navrotzkiy", we also noted that under irrigation the latter has less of a root system than the former. However, without irrigation, the root system of the two varieties is roughly comparable. We present below the results obtained for an area of supply 60 x 5 centimeters.

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	Weight of Large roots	Weight of Small roots	Total weight of roots	Yield of lint	Dry mass - lint	Weight of roots in percent of aboveground mass
Fertilizer without irrigation	9.84	2.86	12.7	14.71	31.21	40.7
Fertilizer plus irrigation during the flowering stage	9.02	3.54	12.5	17.13	41.13	30.39

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Water Regime	Weight of Large roots in kilograms	Weight of Small roots in kilograms	Ratio between weights of large and small roots	Total weight of roots	Above-ground weight in tsentner per hectare	Root weight in percent of above-ground weight
(1)	(2)	(3)	(4)	(5)	(6)	(7)
ROOT SYSTEM OF DIFFERENT COTTON VARIETIES UNDER DIFFERENT CONDITIONS AND PRODUCTIVITY THEREOF WITH AREA OF SUPPLY 60 x 5 CENTIMETERS						
1306 without irrigation	549	626	0.88	1175	74.6	15.8
"Triumf Navrotskiy" without irrigation	618	476	1.3	1094	76.7	14.2
1306 under irrigation	489	394	1.24	883	75.5	11.7
"Triumf Navrotskiy" under irrigation	545	763	0.71	1308	91.0	14.5
THE SAME, WITH AREA OF SUPPLY 60 x 40 CENTIMETERS						
1306 without irrigation	450	576	0.94	926	43.0	21.6
"Triumf Navrotskiy" without irrigation	506	334	1.51	840	47.1	17.8
1306 under irrigation	433	309	1.4	44.2	50.0	14.8
"Triumf Navrotskiy" under irrigation	493	524	0.94	1017	58.8	17.3

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(1)	(2)	(3)	(4)	(5)	(6)	(7)
		THE SAME, WITH AREA OF SUPPLY 60 x 40 CENTIMETERS				
1306 without irrigation	304	311	0.98	615	23.4	27.7
"Triumf Navrotskiy" without irrigation	352	241	1.46	593	26.3	22.8
1306 under irrigation	331	265	1.25	596	27.5	21.8
"Triumf Navrotskiy" under irrigation	390	415	0.94	805	32.1	25.2

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Irrigation thus very strikingly changes the relation between large and small roots of these varieties.

With 1306, the weight of the small roots exceeds that of the large roots without irrigation; in "Iriumf Navrotskiy", on the contrary, this occurs with irrigation.

"Triumf Navrotskiy" was more exigent with respect to moisture, producing a dense network of absorbent roots only under good soil moisture conditions. 1306 Shreder developed a dense network of fine roots without irrigation, and reduced that network under irrigation.

Consciousness of agricultural methods and knowledge of the underground factories of plants and of their requirements will make it possible not only to increase the yield of cotton but also to mark out new paths to the further enhancement of productivity and to develop new methods of progressive agricultural technique.

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COTTON FERTILIZERS IN THE NEW REGIONS

V. E. Aleksandrov

THE SIGNIFICANCE OF FERTILIZER

Fertilizers play a tremendous role in the cotton growing of the Soviet Union. In Central Asia and in Transcaucasia, cotton is grown as a rule with fertilizers.

Tens of thousands of tons of fertilizers are annually applied to hundreds of thousands of hectares. This measure is justified by its very considerable effectiveness. Each kilogram of nitrogen introduced into the soil results on the average in an additional yield equivalent to 3 kilograms of lint.

The application of fertilizer in the new cotton regions has not been studied by the experimental institutions, and consequently down to the present moment fertilizers are still not used in production here.

Nevertheless the development of methods of chemical soil treatment represents a major new achievement of agricultural technology on the path of strengthening cotton growing in the new regions.

Chemical treatment of the soil is particularly important for seed growing purposes. Increasing the coefficient of reproduction of seeds with the aid of fertilizers means accelerating the rate at which the cotton varieties now current will be replaced by new ones of higher productivity and improved fiber qualities.

MINERAL FERTILIZERS

Systematic experiments were commenced in 1930. During the four years from 1930 to 1933, inclusive, over 100 experiments were made at various points in the new cotton areas, embracing various soil types.

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NAME OF POINT	KRAY OR REPUBLIC	SOIL TYPE
Prikumsk NOVNIKhI	North Caucasus Kray	Light chestnut medium loams in association (complexes with solonetzes (up to 10 percent).
Taman' - Zonal Station	Azov-Black Sea Kray	Cis-Asiatic chestnut chernozems
Naurskaya Experiment Point	North Caucasus Kray Mozdokskiy Rayon	Chestnut Soils
Khasav-Yurt, Dagestan Experiment Point	Dagestan ASSR	Dark Chestnut soils
Astrakhan	Lower Volga Kray	Brown Soils
Kherson, Zonal Station	Ukraine, Odessa Oblast	Chestnut chernozems
Skadovsk Experiment Point	Ukraine, Odessa Oblast	Chestnut Chernozems in association with solonetzes.
Brilevsk Experiment Point	Ukraine, Odessa Oblast	Lower Dnepr clay sands.
Akimovsk Experiment Point	Ukraine, Dnepropetrovsk Oblast	Chestnut Chernozems

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Almost all major problems were touched by the study. The themes set were the determination of the areas requiring fertilizer, the forms and amounts to be used, and the manner and time of application. There was only a single question - the technique of application - that remained almost untouched.

Experiments on the technique of fertilizer application were commenced only in 1932.

The results of the experiments showed that it was necessary to study the question of the technique of fertilizer application first of all and only then, against the background of the best methods of application, to experiment on forms and dosage of fertilizers, time of application, etc. Studies of all these themes cannot properly serve to throw light on the questions of chemical soil treatment unless the right technique of application is also employed.

SEARCH FOR AREAS RESPONSIVE TO FERTILIZER AND FORMS OF FERTILIZER

Fifteen experiments were made on this theme, during 3 years, at 9 points. The plan of experiments was in most cases that of Mitcherlikhov, with five variants (0, NPK, PK, NK, NP) with addition of a sixth plot for phosphorus. In the Taman' the full plan of George Vitye was used, with 8 variants (0, NPK, PK, NP, NK, P, N, K).

The norm of fertilizer application was in most all cases 60 kilograms of active ingredients (N, P_2O_5 and K_2O). Excepting at Prikumsk in 1932, all fertilizers were applied by continuous scattering of the material and worked lightly with a zigzag harrow, 1 to 3 days before planting.

This method of surface application of fertilizer appears inexpedient for the new cotton regions, since there is an absence of irrigation here during the growing season which might wash the fertilizer down from the surface to the level of activity of the root systems, but on the contrary rising water action predominates.

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EFFECTIVENESS OF MINERAL FERTILIZERS FOR COTTON IN THE NEW COTTON REGIONS

	Khasav-Yurt, Dagestan		Naurskaya, Mozdokskiy Rayon	Astrakhan		Taman'		Prikumsk			Kherson		Experiment Stations			Mean of Columns I - VII (12 values)	Mean of columns I- X (15 values)
	1930	1531 /Sic/	1930	Bugar 1930	Il'men 1930	1931	1932	1930	1931	1932	1931	1932	Brilevsk 1931	Skadovsk 1932	Akimovsk 1932		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	Yield of Lint in Tsentner per Hectare																
0	10.5	17.1	3.3	12.7	14.8	9.7	14.1	3.7	7.3	15.0	11.6	10.1	4.9	10.9	7.4	10.4	10.2
NPK	11.3	17.6	3.8	14.1	18.1	11.6	16.0	4.1	7.1	19.6	11.6	11.4	5.3	13.2	10.0	11.7	11.7
PK	11.2	18.1	3.5	13.7	17.5	11.7	14.7	4.0	6.3	18.1	10.6	---	5.1	---	---	11.2	---
NK	10.5	17.8	3.5	14.3	17.8	11.5	15.3	4.1	6.6	18.0	11.7	---	5.0	---	---	11.3	---
NP	11.3	17.9	3.4	14.2	18,6	11.4	13.8	4.2	5.8	18.3	12.3	---	6.0	---	---	11.4	---
P	11.3	17.6	---	14.1	15.6	11.8	13.1	---	7.1	16.9	11.4	---	5.1	---	---	---	---
N	---	---	---	---	---	10.3	14.6	---	---	16.7	---	---	---	---	---	---	---
K	---	---	---	---	---	11.6	13.4	---	---	---	---	---	---	---	---	---	---

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
								Yield in Percent									
0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
NPK	108	103	115	111	122	120	113	111	97	131	100	113	108	121	136	111.6	114 .7
PK	107	106	106	108	118	121	104	108	90	121	91	---	104	---	---	107.8	---
NK	100	104	106	113	120	119	108	111	79	120	101	---	102	---	---	109.0	---
NP	108	105	103	112	126	118	98	114	97	122	106	---	122	---	---	109.9	---
P	108	103	---	111	105	122	93	---	---	113	98	---	104	---	---	---	---
N	---	---	---	---	---	106	104	---	---	111	---	---	---	---	---	---	---
K	---	---	---	---	---	120	95	---	---	---	---	---	---	---	---	---	---

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The results of the experiments showed that even with improper technique of application, when any effect of the fertilizer was dependent on chance (frequent favorable rains, etc.), the positive role of chemical soil treatment in increasing the yield of cotton in the new regions was apparent.

As may be seen from Table 38 (page 82) fertilizers almost invariably increased the yield of cotton. In some cases this increase is substantial. The mixture of nitorgen with phosphorus and potash applied at the rate of 60 kilograms per hectare gave an increase of 31 percent in Prikumsk in 1932, in Astrakhan, on the Il'men, of 22 percent in 1930, and of 20 percent in Taman' in 1931.

With the relatively high productivity of cotton under experiment station conditions, the absolute increases in yield assume practical operational significance. Such increases are sometimes expressed by 4.6: 3.3 and 1.9 tsentner per hectare, which should indicate the definite operational importance of mineral fertilizer in the new regions. In these cases the return per kilogram of nitorgen is considerably higher than the mean return for nitrogen content of fertilizer in the old regions.

The return per kilogram of nitorgen was 7.7 kilograms of lint per hectare at Prikumsk in 1932, in Astrakhan, on the Il'men, it was 5.5, and in Taman' in 1931, 3.22 kilograms per hectare.

[For table see page 157]

Thus an effectigeness of fertilizer, expressed by a 20 - 30 percent increase in yield, was noted each year.

Besides the examples of increased yield up to 36 percent, there

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MAXIMUM EFFECTIVENESS OF MINERAL FERTILIZER FOR COTTON IN THE NEW AREAS

Point of Experiment	Year	Yield in Tsentner per hectare without fertilizer	Additional yield due to Fertilizer		Return per Kilogram of nitrogen
			In tsentner per hectare	In percent	
Astrakhan, on the Il'men	1930	14.8	3.3	22	5.5
Taman'	1931	9.7	1.9	20	3.2
Prikumsk	1932	15.0	4.6	31	7.7

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were also examples of slight effectiveness. Thus in one case 15 experiments gave no increase in yield at all, and in other cases there was even a negative effect; the yield was reduced.

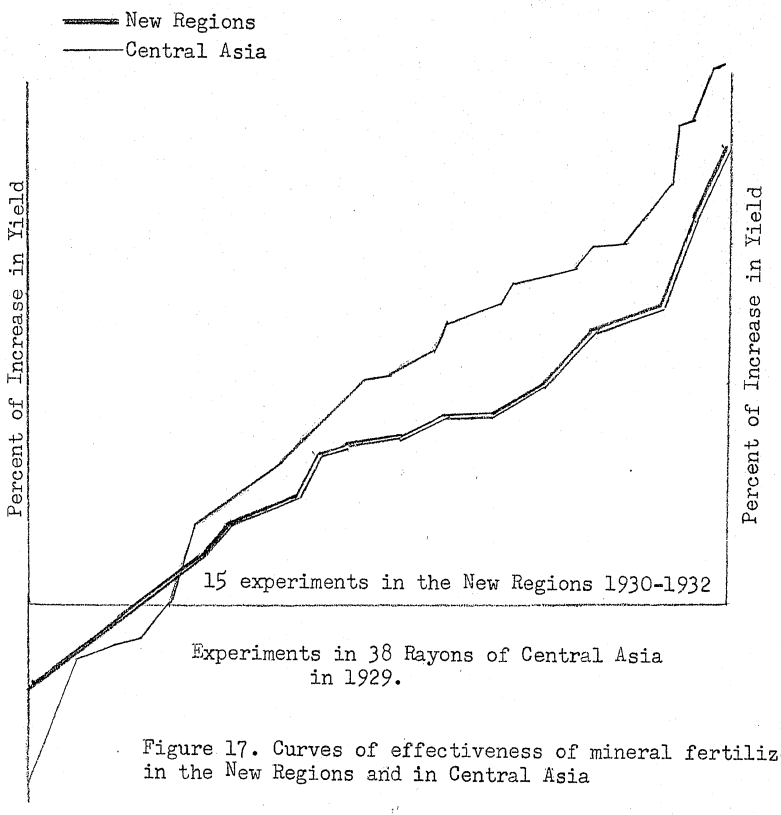

Figure 17. Curves of effectiveness of mineral fertilizers in the New Regions and in Central Asia

On the diagram in Figure 17 two lines are shown. The heavy line shows the increases in yield, arranged in ascending order, obtained in 15 experiments in the new regions from the application of nitrogen, phosphorus and potash at the rate of 60 kilograms per hectare. The second, thin line shows the distribution, in the same order, of the results of experiments made in 38 Rayons of Central Asia in 1929, when 90 kilograms of nitrogen were applied, according to the statistical guide to the effectiveness of fertilizer in Central Asia, issued in 1930 by the Central Asian Fertilizer Station

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As may be seen from the diagram, both lines almost coincide along their entire length.

The mean values are very close together. The mean increase in yield in the 15 experiments in the new regions was 14.7 percent, while in Central Asia for 38 Rayons it was 19.9 percent, i.e. a difference of 1.2 percent in all.

The results are close together not only in percent of increase in yield (difference 1.2 percent) but also in the return per kilogram of nitrogen. The additional yield of lint was 2.5 kilograms per kilogram of nitrogen in the new regions, and 2.8 kilograms in Central Asia.

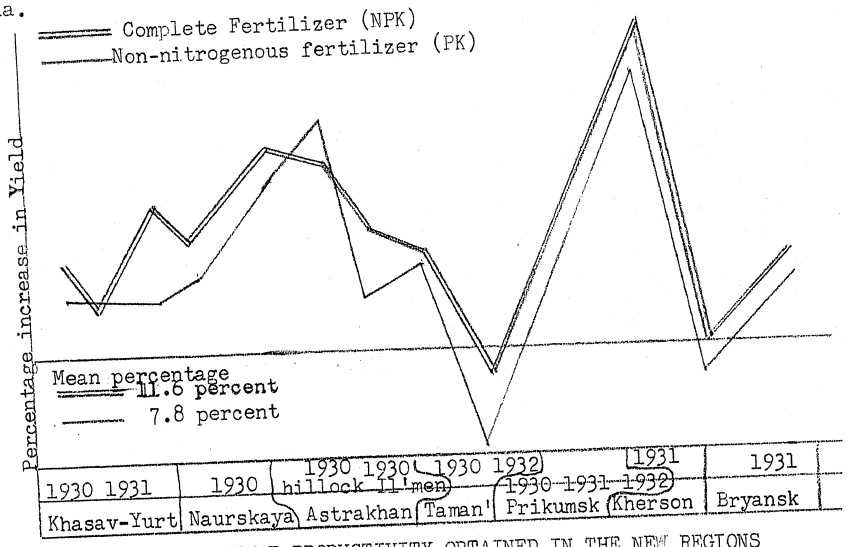

Figure 18. ENHANCEMENT OF PRODUCTIVITY OBTAINED IN THE NEW REGIONS BY USE OF MINERAL FERTILIZERS

Chemical soil treatment has two advantages in the new regions as compared to Central Asia; the action of potash is definitely beneficial which is not observed in general in Central Asia, and secondly it is

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possible to use non-nitrogenous phosphate-potash fertilizers on account of the approximately equal action of each of the three elements in the new regions - nitrogen, phosphorus and potash- while in the old regions increases in yield are obtained mainly with the aid of nitrogen.

On the diagram (Figure 18) the heavy line shows the yield with complete fertilizer (NPK), and the fine line, showing the yield from non-nitrogenous fertilizer (PK), almost exactly reproduces the first line at a somewhat lower level, which graphically illustrates the beneficial effect of non-nitrogenous fertilizers, while the data in Table 41 show that the action of phosphorus and potash sometimes reaches gains of 21 percent.

MAXIMUM ACTION OF NON-NITROGENOUS FERTILIZER (PK)

Name of Point	Year	Increase in Yield	
		In Tsentner per hectare	In Percent
Astrakhan, Il'men	1930	2.7	18
Taman'	1931	2.0	21
Prikumsk	1932	3.1	21

In view of the imperfections in the technique of application, the results of the experiments to determine the fertilizer requirements of the soils in the new regions cannot be considered final or completely satisfactory as proof. The indications obtained during the past three years are plainly under-estimated and may be considered increased in coming years by the application of more perfected methods (the local deep application of fertilizer being studied at the present time, etc.).

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DOSAGE OF NITROGEN AND PHOSPHORUS

Experiments were carried on during two years(1930 and 1931) at five points simultaneously according to three plans:

(a) Mitcherlikh method of determining the soil requirement of fertilizers.

(b) Variable amounts of nitrogen with the amount of phosphorus background remaining constant.

(c) Variable amounts of phosphorus with the amount of nitrogen remaining constant.

The following amounts of nitrogen and phosphorus were used: 45, 60 75, 90, 120 and 180 kilograms per hectare. The unchanged amount of 60 kilograms per hectare was used for nitrogen or phosphorus, respectively.

The results are given in the following table.

/For table see page 162/

Thus the experiment of varying dosage within the limits of 60 to 180 kilograms per hectare produced no marked difference of effect either for nitrogen or phosphorus.

The mean increase of yield for the five points was 8.4 percent for application of nitrogen and phosphorus at the rate of 60 kilograms per hectare, according to Mitcherlikh's methods, while for the optimum dosage of nitrogen (amount shown in table 37) with constant amount of 60 kilograms of phosphorus, the increase in yield was 11.4 percent, or only about 3 percent greater. The optimum dosage of phosphorus gives even less of a difference; 1.4 percent.

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INCREASE OF YIELD OF COTTON GIVEN BY VARYING AMOUNTS OF NITROGEN AND PHOSPHORUS

Name of Point	Year	Increase in yield obtained from NP at 60 kilograms, in experiment by Mitcherlikh method (In Percent)	Increase in yield obtained from optimum dosage of nitrogen with constant amount of 60 kilograms of P_2O_5 per hectare	Optimum dosage of nitrogen per hectare	Increase in yield obtained from optimum dosage of phosphorus with constant amount of 60 kilograms of nitrogen per hectare (In percent)	Optimum dosage of nitrogen per hectare
Khasav -Yurt	1930	8	6	45	13	90
Naurskaya	1930	3	21	120	0	120
Taman'	1931	11	8	120	9	90
Prikumsk	1930	14	11	60	16	60
Kherson	1931	6	10	120	11	90
MEAN	---	8.4	11.4	---	9.8	---

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The explanation can be found only in the application of improper methods of introducing the fertilizer, since it is obvious that if the fertilizer remains on the suface and does not all enter the sphere of action of the root system, its amount is a matter of indifference.

FORMS OF NITROGEN AND PHOSPHORUS

For the same reason (surface application only) as applies to the dosage experiments, the difference in effect of different forms of nitrogen and phosphorus could not appear, failing the conditions for its manifestation.

The results of the experiments with the forms of nitrogen and phosphorus are shown in Figure 19. The left half of the diagram shows the indifference of the forms of nitrogen, since yields are at the same level. Four forms of nitrogen were tried at Prikumsk in 1930, with dosages of 60 kilograms per hectare and 45 kilograms of phosphorus per hectare. Two forms at Khasav-Yurt in 1930, with dosages of 45 kilograms per hectare of nitrogen and 45 kilograms of phosphorus per hectare; and 3 forms at Taman' in 1931, with dosages of 60 kilograms of nitrogen per hectare, without phosphorus.

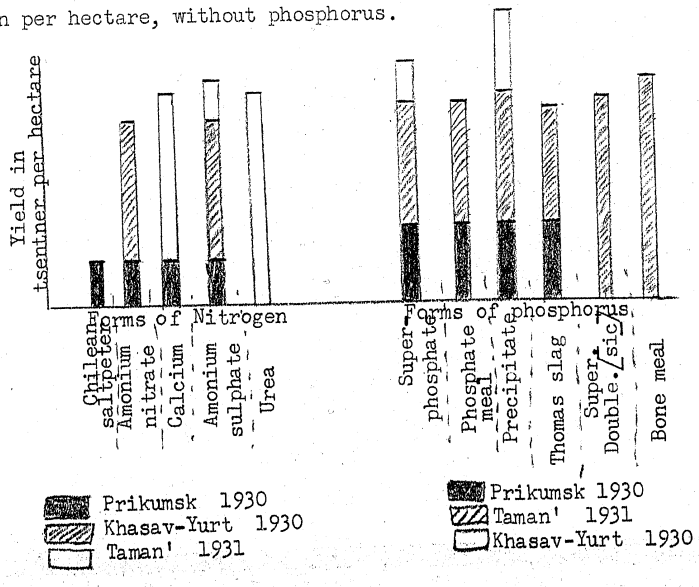

Figure 19. Effect of various forms of nitrogen and phosphorus on the yield of cotton.

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The right half of the diagram shows almost the same results for the forms of phosphorus. Four forms of phosphorus were tried at Prikumsk in 1930 with dosages of 60 kilograms per hectare and 45 kilograms of nitrogen per hectare; 6 forms in Taman with the same dosage of phosphorus without added nitrogen; 2 forms in Khasav-Yurt in 1930 in dosages of 45 kilograms per hectare, nitrogen being 45 kilograms per hectare.

THE TECHNIQUE OF FERTILIZER APPLICATION

The question of method of application is basic in any study of the action of mineral fertilizers in the new cotton regions.

The colossal importance of the technique of fertilizer application was already shown in 1928 by the results of experiments carried out as early as 1928 in Central Asia by the Fertilizer Station (Kaunch). /Statistical Guide to the Effectiveness of Fertilizers in Central Asia. Central Asia Fertilizer Station, 1930./

Method of Application \ Depth of Application	5	10	20	Remarks
	---Centimeters--			
Broadcast	3.4	13.7	20.4	Fertilizer applied
In the rows	9.0	38.5	35.4	before planting cotton

It is clear from these examples that local application of fertilizer, worked in at various depths, increases the percentage of of additional yield due to fertilizer by 1.5 to 3.0 times, as compared to broadcast application. In turn, the depth to which fertilizer was worked in increased this additional fertilizer yield by 4 - 6 times both with local and continuous application.

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Experiments on fertilizer application methods were commenced in 1932 in the new regions. The data shows that the additional yield was amost doubled when fertilizer was plowed into the furrows to a depth of 15 centimeters during the shallow winter breaking, rather than broadcast during the same plowing

INCREASE OF COTTON YIELD DUE TO VARIOUS METHODS OF APPLYING FERTILIZER. KHERSON, 1932

Conditions of Experiment	Lint Yield		Remarks
	In tsentner per hectare	In percent	
Control; no fertilizer	9.3	100	---
Broadcast application of fertilizer during shallow winter breaking	9.9	103	At the rate of 60 kilograms of nitrogen and phosphorus
Plowing fertilizer into the furrows to depth of 15 centimeters during shallow winter breaking	10.4	111	At the rate of 60 kilograms of nitrogen and phosphorus
Application of fertilizer in the spring in the furrows, 5 centimeters from the rows, at a depth of 15 centimeters.	10.8	115	At the rate of 60 kilograms of nitrogen and phosphorus

This experiment, carried out in Prikumsk, showed that local application of fertilizer at different depths produced a satisfactory effect, with yield increments of 20 - 23 percent, and indicating a tendency to strengthened action of fertilizer with increasing depth of application. The gradation between the depths selected was only 2 centimeters, which was too small; this was a shortcoming of the experiment organization and explains the small difference in favor of deeper application; only 3 percent.

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Conditions of Experiment	Lint yield: In tsentner per hectare	Lint yield: In percent	Remarks
Control, without fertilizer	11.9	100	
Application at 5 centimeter depth	14.2	120	
Application at 7 centimeter depth	14.2	120	
Application at 9 centimeter depth	14.6	123	

The high effectiveness of fertilizer at Prikumsk in 1932 is striking. The fertilizer was generally broadcast on the suface and worked in lightly by harrow. Here it must be stated that Prikumsk in 1932 was an exception; in this case the fertilizer was applied with the aid of a sowing drill combine ("Fil'vort-Dedina") the drill furrow openers of which worked in the fertilizer to a depth of 7 - 8 centimeters.

At the present time the work on chemical soil treatment in the new regions is directed mainly towards the study of the action of fertilizers on local and deep application.

In American cotton growing practice, where very high coefficients of utilization are obtained from fertilizers, local and deep application is the usual method.

The applied fertilizer, in the presence of soil moisture is at first rapidly assimilated by the soil microorganisms and passes into the living protein of bacterial bodies. In this form the nutrients are unavailable for the higher plants, and for this reason nitrates are often found to be absent from the soil during the flowering period of the cotton plant, in spite of the application of nitrogenous fertilizers

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during the spring. This happens because the soil bacteria intercept the nutrient elements on their way to the cultivated plants and do not leave them their share of the nutrient elements in mineralized form at the required moment.

When fertilizer is applied locally, the contact surface between applied fertilizer and soil is several times smaller than when it is applied by continuous broadcast, in consequence of which its coefficient of utilization is three times as great, as for instance in the Kaunchy experiment.

Deep application of fertilizer has a long series of advantages.

In the first place, the number of soil bacteria grows less as it goes deeper into the plowed horizon. If fertilizer is introduced below the plowed horizon, for instance at the 30 - 40 centimeter level, it will remain almost entirely untouched by bacteria, awaiting its utilization by the plant roots. In this case full use may be expected to be made of it, with a rise to maximum value of the coefficient of utilization to the maximum.

The mean value of the coefficient of effectiveness for nitrogen in Central Asia is approximately equal to 3, while single experiments give as much as 10 - 15. According to data in the American literature this value has risen to 30 in some experiments.

When the depth of fertilizer application is increased, its introduction beneath the plant to be fertilized is achieved, while broadcast fertilizing produces a fertilizing of the soil.

Deep application makes it possible to introduce fertilizer a

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single time for some years ahead, i.e. to obtain the effects of the same fertilizer on the rotation of a whole sequence of crops.

In the second place, it is an important property of deep fertilizer application that it reaches the depth where there is a moist soil layer and the active zone of the root system. During the summertime, the soil in the new regions becomes intensely dried. By regulating the depth of fertilizer application in accordance with the dynamics of moisture in the various soil horizons, the optimum conditions for the utilization of the fertilizers by the roots of cultivated plants may be attained.

The results of experiments with local and deep application of fertilizers carried out in the Ukraine in 1933 by applying nitrogen together with phosphorus at the rate of 90 kilograms per hectare show that the local application at a great depth resulted in considerable increments of yield, ranging from 62 to 91 percent, while the broadcast application gave 10 percent, a hardly noticeable increment and the usual amount for this method. Increments of this order were responsible for the formerly held opinion that fertilizer produced little effect in the new areas.

[For table see page 169]

Another example, with higher yield and harvest completed before the frosts, is given by the experiment at the Crimean Base, using different methods of applying a mixture of 60 kilograms each of nitrogen and phosphorus per hectare.

[For table see page 170]

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EFFECTIVENESS OF LOCAL APPLICATIONS OF FERTILIZERS AT KHERSON

Method of Application	Yield of Lint in Tsentner per Hectare	Increment of yield in percent
Control; no fertilizer	0.07	---
Broadcast before shallow winter breaking	0.08	10
Plowed into furrows during shallow winter breaking	0.11	62
5 centimeters to the side of the rows, at 15 centimeter level, during sowing	0.12	68
On both sides of rows, 5 centimeters away, at 15 centimeter level, during sowing	0.13	91

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EFFECTIVENESS OF LOCAL APPLICATION OF FERTILIZER IN CRIMEA

Method of Application	Total Yield of Lint		Yield before the pre-frost Period		Pre -frost yield in percent of total yield
	In tsentner per hectare	Percentage increment	In tsentner per hectare	Percentage Increment	
Control; no fertilizer	1.90	---	0.14	---	7
Broadcast before shallow winter breaking	2.33	15	0.66	388	30
Plowed into furrows during shallow winter breaking	3.22	68	0.92	582	29

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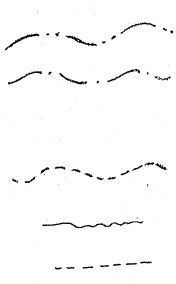

Lines of Equal Mean Annual Temperatures (Isotherms)

Lines of Equal Mean Annual Precipitation (Isohyetal Lines)

Lines of Equal Frost-Free Periods, in days

Rivers

Railroads

Figure 2. CLIMATIC MAP OF THE NEW COTTON REGIONS OF THE USSR

PRECIPITATION

The new cotton areas are characterized by a wide range of variation in annual precipitation; from 169 millimeters in Astrakhan' to 647 millimeters in Krasnodar (Table 11 on page 28), but a certain uniformity is observed in the distribution of this precipitation among the various months of the year. Thus there is more precipitation during the summer months and generally during the summer half of the year than during the winter half. The smallest percentage of the annual precipitation falls during early autumn, that is during the second half of August and September. In some places this is also true of October. Such an average distribution of precipitation is very favorable for the harvesting of cotton crops. With annual precipitation under 300 millimeters, unirrigated cotton growing becomes doubtful, but this conclusion is far from having no exceptions. Thus on the Ukrainian seacoast (Skadovsk, Ochakov, Genichesk), precipitation is 248 - 299 millimeters, and yet these places belong to the areas which are most predominately devoted to cotton growing in the Ukraine. On the other hand, Dagestan has precipitation ranging from 361 millimeters in Derbent to 498 millimeters in Khasav-Yurt, and yet most of the cotton

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In this case broadcast application gave the insignificant increment of 15 percent, while local application gave 69 percent. The action of fertilizer was accompanied by acceleration of maturation by 10.5 days as compared with the control, and in consequence the pre-frost harvest was sharply increased. The latter was almost 6 times as great as the control with local application, and about 5 times with broadcast application. These results were obtained under the exceptionally unfavorable conditions of 1933 for cotton growing in Ukraine and Crimea, and of course cannot be used as the basis for final evaluation of the effectiveness of fertilizer in the new regions.

Deep fertilizer application has the very useful quality of being readily adapted to mechanization, since it may be done simultaneously with plowing, sowing or cultivation of the cotton plant, according to the need for fertilizer at a given time.

The method of scattering fertilizer by hand out of a pail, which is widely used in Central Asia, must be replaced in the near future by mechanized methods of application.

The Mechanization Department of NOVNIKhI (Comrade Bronitskiy) has developed a device for attachment to drills or plows for applying fertilizer in solution or in powder form during cotton sowing or during plowing.

Two extra shoes for fertilizer application are attached to the Armalitov two-row cotton seeding drill (Figure 20) through which fertilizer is fed through a rubber tube in a solution or powdered form. The fertilizer in the tank is stirred by an agitator activated by a chain drive. The shoes introducing the fertilizer are adjustable by means of a yoke attachment in a lateral direction along the chassis

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of the drill and also for depths up to 20 centimeters.

The same device may be readily transferred from drill seeder to plow [The plowshares have been removed from the plow, as the photograph was taken after applying fertilizer to a plowed field] for applying fertilizer during the plowing. It can be adjusted to a depth of 40 centimeters.

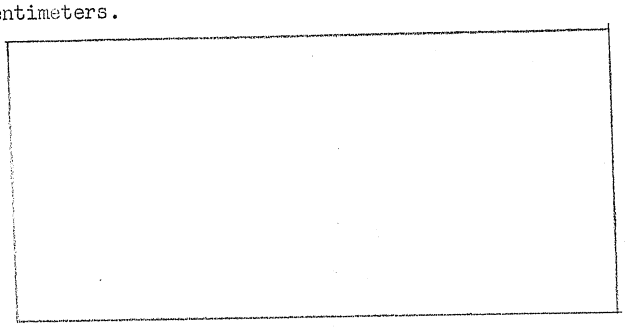

Figure 20. Device for applying mineral fertilizer with a two-row Armalit seed drill seeder. The two shoes (AA) apply the fertilizer, which is introduced from the tank B through the rubber tubes CC.

A drill seeder with the device for applying fertilizer was tested in the spring of 1933 at Prikumsk, where it performed excellently in handling cotton planting and simultaneous fertilizer application. But application of fertilizer in liquid form suffers from the great disadvantage that 40 - 50 pails of water are needed to dissolve the fertilizer for a single hectare, which represents an extraordinary burden under operating conditions. The device is more suitable for application of fertilizer in the dry form, as is done in American cotton-growing practice. In the United States fertilizer is applied to cotton in small amounts three times a year, which increases the coefficient of fertilizer utilization.

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But use of fertilizer in liquid form also has many advantages, since it allows the simplification of fertilizer manufacturing processes.

Figure 21. Device for applying mineral fertilizer by plow. Shoe (A) through which fertilizer is applied, coming from the tank (B) through the tube (C).

There are two stages in the process of preparation of manufacturing nitrogenous fertilizers. The first is the combination of the ammonia with an acid, usually sulphuric acid, after which the finished product is obtained ready for use as fertilizer in the form of ammonium sulphate.

More infrequently, the ammonia is combined instead with nitric acid. The product - ammonium nitrate, or ammonia saltpeter - has the disadvantage of being highly hygroscopic.

The use of sulphuric acid for the sole purpose of fixing amonia as ammonium sulphate represents a great expense in fertilizer manufacture. Sulphuric Acid, moreover, is in short supply for other branches of industry. The method of applying fertilizer in liquid form allows the use of ammonia without combining it with sulphuric acid. the academician D. N. Pryanishnikov reports the following on this subject [7] "Basic tasks in the application of Chemistry to Agriculture". Leading article in the Fertilizer Handbook, issued in 1933 by the NIU NKP under the editorial supervision of academician E. V. Britske and L. L. Balashev [7] :

"We may also recall the suggestion that ammonia in aquaeous solution be used directly as fertilizer. This idea came up in the Nitrogen Institute in connection with the question of the long-distance

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transportation of liquified ammonia in tanks; to reduce the pressure it might be absored into ammonium or calcium nitrate. Such "ammoniates" could be transported far more safely than pure ammonia, and they could then be used on the site after some addition of water as a row fertilizer applied during planting(the Omsk Agricultural Machinery Experiment Station is now working on such combine drill seeders)".

The question of whether to use fertilizer in liquid or dry form will thus be decided after careful study of the technology of fertilizer manufacture, its transportation to the place of use, and economic computation of the relative costs.

The NOVNIKhI drill seeder is one of the types already developed for these purposes, which is in need of a certain amount of modification to adapt it for practical operational use.

ORGANIC FERTILIZERS

Decomposition of the organic constituents of manure proceeds slowly in the extremely arid belt of the south of the USSR, and their influence is conserved for very long periods. For instance, in experiments at the Ukrainian Zonal Station (Kherson Area), manure was last applied in 1915/From 1901 to 1915, 2400 puds of manure per desyatin were applied to the fallow field in a three field system of crop rotation. Consequently, during 15 years, a total of 12,000 puds were applied in the course of five applications_7, and to this day, 16, 17 and 18 years afterwards, its after-effect is still observed.

In 1931 cotton gave an increment of 37 percent, 4.3 tsentner per hectare, for the manure applied 16 years before; in 1932, 17 years afterwards, it still gave an increment of 27.7 percent, or 2.6 tsentner per hectare.

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Such long and powerful action of manure fertilizer should rather be considered soil melioration rather than a mere cultural practice.

Where sources of manure are available, it makes sense to apply it in large amounts under cotton plantings once every ten or twenty years.

The former Kherson Station, on the basis of long-term data on the calculation of the effect of manure, was unable to reach this conclusion only because the calculations referred to grain crops and not to cotton, which was planted for the first time in this experiment only in 1931.

The positive action of manure fertilizer begins in the first year after it is applied and is more powerful than that of mineral fertilizers.

The following experiment was carried out at Kherson in 1932:

/For table see page 1767

The manure and mineral fertilizers were applied in spring before planting. Even with such late application of manure, when only a short time still remained for its mineralization, it still produced a greater effect than mineral fertilizers. The action of manure was accompanied by considerable acceleration of vegetative growth, which was reflected in the increase of the pre-frost harvest, the increment of which amounted to 42 percent.

The experiment in 1933 at the Taman' Zonal Station is another example of the effect of manuring.

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RELATIVE EFFECT OF MANURE AND MINERAL FERTILIZER

Fertilizer	Total Yield of Lint			Pre-Frost Period		
	In tsentner per hectare	Increment		In tsentner per hectare	Increment	
		In tsentner per hectare	In percent		In tsentner per hectare	In percent
Control; no fertilizer	12.2	---	---	6.4	---	---
Manure at the rate of 180 kilograms of nitrogen per hectare	16.1	3.9	32	8.6	2.2	42
Ammonium sulphate at the rate of 180 kilograms of nitrogen per hectare	14.1	1.9	14	6.2	-0.2	-4
Mineral fertilizer NPK	14.8	2.6	21	7.6	1.2	18

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EFFECT OF MANURING DURING THE FIRST YEAR

	Total yield of lint In tsentner per hectare	Increment In tsentner per hectare	Increment In percent
Control without fertilizer	6.6	---	---
Manure - 20 tsentner per hectare	9.0	2.4	36

Since large quantities of manure are unavailable on a large-scale mechanized farm, other ways must be sought of obtaining organic substances instead of manure but with the same specific properties of melioration.

The favorable qualities of the perennial grasses, for instance alfalfa, are well known. /N. I. Bykov, The Influence of Alfalfa and Continuous Cropping of Cotton on Soil Structure./ By plowing under alfalfa as a green manure, improvement in structure and porosity of the soil is obtained, together with enhancement of the yield of various crops, including cotton (Central Asian experiment).

The wastes of agricultural production - straw, cotton stalks, locks of cotton bolls, sea weed, etc. - may serve as another source of organic material, besides manure.

To avoid denitrification (in the broad sense of the term) during the first year after manure isplowed under, the supplementary use of small amounts of mineral fertilizers, nitrogen and phosphorus, has been suggested in conjunction with manure, as an attractive nutrient for the bacteria that transforms the carbon of the carbohydrates of the straw and cotton stalks into an organic mass. If this question is decided in the affirmative, new prospects of increased cotton yields will be in sight.

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The experiments with plowing under of cotton stubble and straw, without a primer of mineral fertilizers showed no negative effects.

Under the conditions of the arid belt of the south, the processes of decomposition take place slowly, and the biological fixation of the mobile soil nitrogen during decomposition is not so great as to check the development of crops

TAMAN' ZONAL STATION, 1933

Fertilizer	Total Yield in Tsentner per hectare	Increment in percent
Control	6.0	---
Cotton stalks, 60 kilograms per hectare	7.0	6
Kamka (an alga)	7.0	6

Cotton stalks and kamka algae applied at the Taman' Zonal Station in the autumn of 1932 gave slight increases in cotton yield in the following season, 1933 - amounting to 6 percent. (Table 45). In the autumn of 1933, when the cotton plants were taken up during the plowing of the field, undecomposed remains of stalks were still encountered, showing how slow were the processes of decomposition.

/For table see page 179/

In another experiment at Kherson cotton stalks and straw were applied in the spring before planting. Even in this case there was no reduction in yield, and a slight increment of 3 - 5 percent was obtained. (Table 46).

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UKRAINIAN ZONAL STATION 1932

Fertilizer	Total yield in tsentner per hectare	Increment		Pre-frost yield in tsentner per hectare	Increment	
		Absolute	Percentage		Absolute	Percentage
Control	12.2	---	---	6.4	---	---
Cotton stalks 16 kilograms per hectare	12.8	0.6	5	6.9	0.5	7
Straw, 16 kilograms per hectare	12.6	0.4	3	7.0	0.6	9
Manure	13.9	1.7	13	7.6	1.2	18

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As a positive feature the acceleration of maturation of cotton must be noted. The total increment is included in the pre-frost harvest, and amounted to 0.6 - 0.5 tsentner per hectare, or 7 - 9 percent.

These two examples of plowing under cotton stalks cannot guarantee against cases of unfavorable action by this procedure. In some cases which are favorable for intensified decomposition, for instance, sharply increased precipitation may result in a reduction of yield comparable to that shown by the 1933 flower-pot experiments at Prikumsk.

YIELD OF LINT IN GRAMS FROM POT-GROWN PLANTS

Fertilizer	Soil Moisture in percent of Optimum Value	
	50	70
Control	5.9	9.7
Cotton stalks, 30 grams per pot	6.7	8.7

In a dry environment (50 percent of optimum moisture content) comparable to the field experiments, the yield increment was 19 percent. The cotton stalks in the pot failed to decompose completely during the summer. In each environment (70 percent of full moisture content) where decomposition was better, 10 percent diminution of yield was obtained.

The numerical data on the experiments with organic fertilizers appears very modest in extent. Consequently the question of organic fertilizers at the present time is still open and its study has just commenced. Therefore all judgements on the subject presented here must be carefully reinforced by suitable experimental evidence.

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FERTILIZERS AND THE DEVELOPMENT OF THE COTTON PLANT

Fertilizer introduced into the soil acts on the internal organization of the plant structure, producing a number of external modifications in it. Increase in the yield of plants subject to fertilizer action is one of the consequences of these modifications, namely:

First, increase of productivity is as a rule accompanied by accelerated vegetation.

In pot experiments this acceleration attained values of over 20 days.

SPEEDING THE DEVELOPMENT OF COTTON GROWING WITH FERTILIZERS

Points	Fertilizer	Number of days by which onset of maturation was accelerated
Astrakhan (Hillocks), 1930	NPK	24
Astrakhan (Hillocks)	NP	20
Kherson, 1930	N	3
Kherson, 1931	NP	9

In field experiments, the acceleration observed amounted to 10 days.

Acceleration of maturation is usual in cases where there is a substantial effect on productivity. In cases where no increment of yield has been noted after use of fertilizer, or only a small increment, there is usually also no acceleration of maturation.

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This indicates that fertilizers in the new regions act like other methods of cultural practice to accelerate the vegetation of cotton. Since the new regions have, as a first prerequisite, heat, which is almost a function of productivity, it is only natural that the head start in vegetation given to cotton plants by vernalization or fertilizer should be accompanied by increment in the yield.

Secondly, there has been noted a specific effect of mineral fertilizers in reducing disease of the cotton plant.

The extent of gummosis was studied during an experiment with fertilizers in 1932 at Prikumsk. The results showed reduction of gummosis to result from fertilizer application to the cotton plant.

REDUCTION OF GUMMOSIS AND MORTALITY BY FERTILIZING THE COTTON PLANT

Form of Fertilizer	Number of Plants on plot dying from gummosis	Mortality in percent
Control; no fertilizer	156	24
Nitrogen - phosphorus - potash	38	9
Nitrogen - potash	41	10
Phosphorus - potash	44	10
Nitrogen - phosphorus	74	16
Nitrogen	75	16
Phosphorus	77	16

The use of nitrogenous and phosphate fertilizers halved the number of plants dying of gummosis. Potash played an especially important role in reducing the incidence of gummosis. In all [redacted] fertilizer combinations containing potash, it was less than one quarter of that noted in the control

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Such action by mineral fertilizers to reduce fungus diseases of cotton plants must unqualifiedly be held to exert an influence on its productivity as well, the more so as the density of stand of the plants is modified in this case.

Mortality was reduced by 8 percent by application of nitrogen and phosphorus, and by 15 percent on application of potash.

It may be noted as a general conclusion that it is most necessary to work up as rapidly as possible the questions involving chemical treatment of the soil in the new cotton regions as a new weapon in the struggle for high yields in the socialist fields, with special attention to working out the question of the technique of deep local application of fertilizers and also the question of the best periods for their application.

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THE INFLUENCE OF ALFAFA AND CONTINUOUS CROPPING OF COTTON ON SOIL STRUCTURE

(Work done in 1931 at Dagestan Base (formerly Dagestan Zonal Station).

N. I. Bykov

The problems involving increased emphasis on the cotton component of crop rotations - increased intensity of cotton cultivation - still await scientific solution. The field experiments on continuous cropping of cotton, under way now for six years at Khasav-Yurt, have not yielded a clear and distinct answer as to the possibility of this practice.

At the Dagestan Zonal Station a deeper investigation of this problem was commenced by the parallel study of the influence of alfafa and continuous cropping of cotton on soil structure, which constitutes the decisive factor in the biological activity of the soil and of agricultural plants as well.

OBJECTS OF INVESTIGATION

Three basic forms of cultural soil condition were the objects of the investigation: continuous cropping, six-field crop rotation, and alfafa.

The field under continuous cropping of cotton, started in 1926, gives high yields every year, showing what the possibilities are for continuous cropping of cotton during the course of a considerable number of years with no unfavorable results apparent on summary inspection.

The six-field crop rotation, recommended for former cotton-fields in the foothill zone of unirrigated cotton growing, was

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started in 1926 with the following rotation:

1. Green fallow in vetches.
2. Winter wheat.
3. Cotton.
4. Soy Bean.
5. Cotton.
6. Oats.

The third object of the study was a field sown with Turkestan alfafa in 1928 and not tilled at all, with the exception of a light shallow plowing in autumn of 1930.

All three fields had rich dark-chestnut carbonate loams, the structure of which could be judged from a soil profile taken near the continuous cotton cropping field.

The A horizon was of dark chestnut color with brown tinge, of granular structure (or more precisely of stratified granular structure) and of mellow texture. Its mechanical composition was loamy; the transition to horizon A 2 was so gradual as to be hardly noticeable; its thickness was 22 centimeters. Harizon A 2 was lighter in color, also with a tinge of brown, of crumble-granular structure; packing was observed at lower levels of this horizon; mechanical composition loamy; thickness 25 centimeters. Horizon B 1: color light chestnut, with tinge of gray; texture crumbling; marked packing of entire horizon; structure somewhat fissile; segregation of carbonates (pseudomycellar) observed; considerable number of worm-holes; mechanical composition loamy; transition to next horizon clear-cut; thickness 24 centimeters. Horizon B 2: chestnut to pale yellow in color; texture crumbling, structure somewhat fissile; segregation of carbonates in form of beloglazok; [small white nodules?] large shrew passages; thickness 25 centimeters. Horizon C; color

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light chestnut with tinge of gray; structure dense and somewhat fissile; considerable segregation of beloglazok; mechanical composition loamy.

Note: Efflorescence of chlorides strong on horizon A 1 and continuous on the other horizons.

ELEMENTS OF THE INVESTIGATION

There are two ways in which the study of soil structure may be conducted. The first is to regard soil structure as divisibile into separate units (aggregates), different in size and form (S.A. Zaknarov); i.e. the morphological approach to the study of structure, by dividing the sample of soil into fractions according to the size of the structural elements and classification of soil structure according to content of aggregates of various diameters and of single grains.

The second method of study follows from the conception of soil structure as the relation of capillary and non-capillary porosity, the decisive significance of which has been demonstrated within exceptionally convincing manner by the researches on the TSKnA experimental field. This relation predetermines the expression and tendencies of all physical, chemical and biological processes in the soil, thus identifying the concept of soil structure with that of the texture of the soil as the relation of capillary and non-capillary porosity.

Thence follows the physiological essence of structure and the special methods of study worked out by TSKnA, of which the basic principle is the taking of samples"of undisturbed structure", and in which the general capillary and non-capillary porosity are the elements of investigation.

To obtain a more complete picture, the study of soil structure

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was carried on by these two parallel methods, embracing both morphological and physiological elements of soil structure, as well as the stability of soil aggregates, defined as the capacity of structural elements to resist the disintegrating action of water (Vil'yams).

As is generally known, soils of unstable structure are rapidly pulverized, are easily washed away by rains, form incrustations and lose all the advantages of structured soils.

The basic elements of the investigation thus appear to be: morphology of structure (quantitative and qualitative analysis of structural elements), total porosity, capillary and non-capillary porosity, and stability of structure.

EXPERIMENTAL PROCEDURE

The Puchner method was used as the basis in the morphological study of structure.

Batches of soil weighing 200-300 grams were first strewn from a height of 1 meter and then separated into fractions by sifting through sieves of sizes corresponding to the structural elements.

Each analysis was repeated twice, i. e. two batches were taken from each sample.

The samples were taken from 10 points in a field, arranged in checkerboard order. 5 samples were taken at each point at the depth of the plowed horizon (20 centimeters).

A total of 150 samples was thus taken from the three fields. Quantitative (structural) analysis and qualitative estimation of the separate structural elements was carried out on these samples.

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The study of porosity was made by the established method worked out at the TSKnA Experimental Field, using soil samples "of undistrubed structure." Instead of special drills for taking the samples, ordinary cylinders of galvanized Iron, 10 centimeters in diameter and 20 centimeters high were used, and proved entirely adequate for the purpose. Five determinations of porosity were made in each case.

Determination of structural stability was by the method developed by Tyulin (Perm'), by which the large aggregates are determined after capillary saturation by "bathing" in sieves.

A few modifications were made in this method; thus the taking of an intermediate sample from unscattered soil was eliminated. The batches of soil were saturated on filter paper and not by placing in a sieve over water (Sobolev).

The aggregates not washed down were transferred to a glass jar, and thence to the filter paper.

After filtration, the soil was dried in a thermostate at 100 - 105 degrees and weighed.

The quantities of aggregates not washed down was calculated in percent of an absolutely dry batch with correction for the number of mechanical particles larger than 0.6 millimeter.

Only four fractions were selected for analysis. Their size is shown in the corresponding tables.

Five determinations were made for each structural fraction separately, on 30 gram soil batches. Each batch was "bathed" 30 times in a 0.5 millimeter sieve.

RESULTS OF THE INVESTIGATION

Morphology of structure. The results of the investigation of

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soil morphology and the numerical data for the separate elements are shown in the diagram (Fig. 22) and the corresponding table, and indicate a definite relationship between soil structure and the various cultural states of the soil. In the given instance, indubitable improvement of structure by alfafa cultivation is emphasized, while, on the contrary, continuous cropping results in considerable deterioration in the composition of the structural elements, by way of pulverization; the dust fraction is almost doubled thereby (10.18 to 19.40 percent).

The composition of the structural elements of soil in the six-field crop rotation shows that rotation has no particular influence on imporvement of soil structure, since the total dust fractions is 19.4 percent after continuous cropping and 19.3 percent after crop rotation; and on the whole the data indicate that while soil structure after alfafa may be characterized as crumble-granular, it may be characterized as granular-dusty after crop rotation or continuous cropping.

The structural elements of all the objects under study may be classified, according to external appearance, into two groups; the first is composed of flat crumbs with smooth surfaces and clearly defined corrugations along one axis; while structural elements of the second group has an apparently irregular outline with uneven surface, as though corroded, often with minor granulations, nodules and cylinders, which are composed of worm-excrement.

FIG. 22 INFLUENCE OF ALFAFA, CROP ROTATION AND CONTINUOUS CROPPING ON SOIL STRUCTURE

_____ Alfafa

\- - - - - - Continuous Cropping

. . . . . Crop Rotation

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Thus, while the first group of form of structured elements may be considered the primary group, produced by dynamic forces, the second form of structure, of later formation, is obviously the result of worm activity.

(see figure #2)

The total porosity appears directly to reflect the results of the structural analysis.

The greater the pulverization of the soil, the lower the porosity, and conversely, lower pulverization of the soil results in greater porosity.

Increased porosity is observed when alfafa is grown, while a distinct reduction in its value occurs on continuous cropping.

The six-field crop rotation however given results close to those for continuous cropping, since the small, insignificant difference between the mean values for the two may fall within the limits of experimental error.

CAPILLARY AND NON-CAPILLARY POROSITY

The total porosity is expressed by the sum of capillary and non-capillary interstices. The parts played by these in the life of the soil and in plant life are not the same.

Capillary porosity conditions the supply of soil moisture (if the surface capillaries are broken down) and the passage of moisture and nutrients into the plant roots, while non-capillary porosity assures a favorable atmospheric regimen and the penetration of moisture into the soil, which in turn assures "a successful approach to the resolution of the antagonism observed between water and air in the soil: each of them taking its own share of the porosity, moisture taking the capillary porosity,

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TOTAL SOIL POROSITY IN PERCENT OF ITS VOLUME

Continuous Cropping	Crop Rotation	Alfalfa	Remarks
49.07	49.38	55.84	Analyses and computation by V. V. Maloyan.
51.06	52.84	55.19	
50.23 Average 50.75	51.77 Average 51.94	55.15 Average 55.65	
52.27	52.19	56.54	
50.81	58.54	55.52	

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RELATIONSHIP OF STRUCTURE TO CULTURAL CONDITION OF SOIL

(Analysis and computation performed by V. V. Maloyan and V. G. Bakhmenin)

Characteristic of Parcel	Over 7	7 - 5	5 - 3	3 - 1	1 - 0.5	0.5 - 0.25	Under 0.25
Continuous Cropping	20.4 - 4.9	8.7 ± 0.9	9.5 ± 0.9	26.1 ± 1.6	14.9 ± 1.7	10.2 ± 1.5	9.2 ± 1.2
Crop Rotation	23.4 ± 5.1	8.4 ± 1.3	9.3 ± 0.8	24.6 ± 1.0	14.7 ± 1.6	11.6 ± 2.0	7.7 ± 2.0
Alfalfa	38.3 ± 7.1	8.4 ± 1.2	9.0 ± 1.7	22.2 ± 4.4	11.1 ± 1.8	6.2 ± 1.0	4.0 ± 0.7

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and air the non-capillary porosity" (S.A. Zakharov).

In the metaphorical language of Professor Kvasnikov, the network of capillary interstices forms a peculiar system of "blood circulation", through which uninterruptedly courses the "blood" of the soil - the soil solution (liquid phase). The network of non-capillary interstices represents a "respiratory" system through which moves the soil air.

These elements of soil structure play so exceptionally important a role as to predetermine all of the most important soil processes.

Passing now to the consideration of the figures presented in the tables, a definite relationship again appears between pulverization of the soil and the values for capillary porosity and also a distinct and regular variation of capillary porosity with the various different cultural conditions of the soil.

CAPILLARY AND NON-CAPILLARY POROSITY OF THE SOIL IN PERCENT OF ITS VOLUME

Continuous Cropping		Crop rotation		Alfafa		
CAPILLARY	NON CAPILLARY	CAPILLARY	NON CAPILLARY	CAPILLARY	NON CAPILLARY	REMARKS
41,76	7,31	41,67	7,71	39,37	16,47	Analyses and computation by V.V. Maloyan
43,28	7,78	42,21	10,63	36,61	18,58	
42,51	7,72	42,04	9,73	39,07	16,08	
43,95	8,62	43,74	8,45	39,01	17,53	
43,30	7,51	44,44	9,10	37,96	17,56	
Av.42,96	7,79	42,82	9,12	38,40	17,24	

The more the soil is pulverized, the greater the capillary porosity, and, on the other hand, a lower dust content of the soil results in lower capillary porosity and increased total and non-

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capillary porosity.

The maximum capillary porosity of the soil results from continuous cropping. Crop turnover [rotation?] reduces this by an insignificant amount. Finally, alfafa reduces it sharply.

The values of non-capillary porosity have an inverse relation to those for capillary porosity, and, combined with the latter, compose the quantity known as total porosity.

Relative Non-Capillary Porosity. Starting with the premise that soil moisture and soil air are equally important, the significance of capillary and non-capillary porosity should similarly be considered equal.

If the soil had only capillary porosity, it would be impermeable to water and air; if it had only non-capillary porosity, it would be permeable to water and air; incapable of retaining water or giving it up again to the root-inhabited layer. Though well supplied with air, such a soil would have no water and could not support life.

There is thus for each soil an optimum ratio between capillary and non-capillary porosity, which ratio results in optimum conditions for plant life.

This optimum ratio has been noted, during the work at the TSKnA Experimental Field, at more than half for non-capillary porosity when total porosity is 50 percent; non-capillary porosity thus being equivalent to 25 percent of soil volume.

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NON CAPILLARY POROSITY IN PERCENT OF TOTAL POROSITY

CONTINUOUS CROPPING	CROP ROTATION	ALFAFA
14,90	15,61	29,49
14,24	20,11	33,67
15,37 value 1534	18,79 value 1754	29,16 value 30,99
16,40	16,19	31,00
14,78	17,00	31,62

The results of the investigation show the most favorable ratio between capillary and non-capillary porosity to be assured by growing alfafa.

Structural Stability. At the present time, the term structural stability means the capacity of soil aggregates to resist the disintegrating action of water (Vil'yams).

Structural stability is due to "the release of calcium as the cathion Ca" from organic compounds by the composition of the remnants of dead roots, and its absorption by the amorphous, colloidal humus. The colloids containing the bivalent cathions so absorbed, including CA", lose the capacity of dispersing their granules in water, and form colloidal solutions. Under all circumstances they become insoluble in water, and, therefore, amorphous, colloidal humus, after absorption of CA" cathions, cements the soil aggregates with the elastic and absolutely insoluble cement, which also gives the soil crumbs stability; the property of not disintegrating in water" (Vil'yams).

Structural stability is thus due above all to the presence of organic remains in the soil, and consequently it will be at maximum when the plowed horizon is rich in organic matter.

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Alfafa leaves the largest amount of organic matter in the form of root residues, while continous cropping of cotton leaves only an insignificant amount of organic matter in the plowed horizon. It is entirely clear that the greatest structural stability is observed with alfafa.

There is no definite relation between structural stability and the separate structural fractions; whence only the methodological conclusion can be drawn that for purposes of aggregate analysis soil samples of mixed fractions can entirely define it.

A distinct picture of definite regularity is observed however in the data for horizontal rows, showing that alfafa growing results in a more stable structure than continuous cropping or crop rotation.

Size of structural elements	PERCENTAGE OF AGGREGATES NOT WASHED OUT		
	Continuous Cropping	Crop Rotation	Alfafa
1--5.....	82,00 + 1,60	79,4 + 0,79	89,73 + 1,17
5--3.....	81,89 + 1,66	80,26+ 1,20	89,64 + 0,88
3--1.....	81,42 + 2,04	82,28+ 1,48	88,27 + 0,91
Average.....	81,72 + 1,45	81,81+ 1,18	89,38 + 1,03

CONCLUSIONS

The following conclusions may be drawn from the experimental data.

1. There is a definite relation of dependence between soil structure and the different crop plants.

2. Continuous cropping of cotton leads to deterioration of soil structure in all elements of the investigation.

3. Alfafa growing aids in the regeneration of soil struc-

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ture by improving the quantitative composition of structured elements, increasing the total and non-capillary porosity, reducing capillary porosity, creating the most favorable ratio between capillary and non-capillary porosity, and distinctly increasing structural stability.

4. Six-field crop rotation without perennial grasses is of no particular value in reestablishing soil structure.

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SOWING AND MANAGEMENT OF COTTON IN THE NEW AREAS

P. A. Yakhtenfel'd

The yield of lint in the New Cotton Areas still remains at an inadmissably low level.

Yields are obtained every year at the Zonal Stations and bases distributed throughout the entire cotton belt of the New Areas which are 6 to 8 times the mean operating yields.

Dozens of the best kolkhozes obtain, year after year, high yields, close to these of the experimental institutions.

This spread between mean yields and maximum yields will undoubtedly be liquidated during the next few years.

The results of the experience accumulated by the institutions for scientific research and by the best farms of the young cotton production branch in the New Areas will help to liquidate this spread very speedily.

NOVNIKHI, with its network of Zonal Stations and Bases throughout the New Cotton Areas of the Ukraine, Crimea and North Caucasus, has obtained basic results during these years of work (1931-1933) that clarify the peculiar features of the technique of the cultivation of cotton in the most northerly cotton region of the world.

The technique of cotton growing in the New Areas is substantially different from that used in the irrigated cotton growing areas of Central Asia and from that used in the cotton belt of North America.

It is an urgent task to equip all workers in the New Cotton Areas with a knowledge of these peculiarities.

Since this work of orientation is on the whole based on the results of numerous field experiments, the basic elements in

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the methodology of such experiments must here be indicated.

The overwhelming majority of the experiments are repeated six to eight times.

In most experiments the plots are about 200 square meters. Almost all experimental data are processed by the method of Styudent, which allows us to rely mainly on the most reliable data and to reject all data open to any doubt.

All the experimental institutes succeeded in attaining exceptionally high accuracy in 1931 and 1932 ($\pm$ 1 to 5 percent in most experiments).

1933 gave less reliable results, especially in the Ukraine, where irregular mortality and rotting of the bolls under the exceptionally unfavorable conditions of that season gave a very low experimental accuracy ($\pm$ 8 to 12 percent).

PREPARATION OF SEED FOR SOWING

An external peculiarity of the seed of the commercial varieties of cotton, as distinguished from the other crop plants of the New Areas, is the presence of fuzz.

The presence of this fuzz, which cannot be removed by current mechanical methods of ginning and delinting sharply distinguishes cottonseed from the seed of other field crops and requires a number of special cultural practices.

Among the other peculiarities of cottonseed which strike the eye, its relatively low specific gravity should be mentioned. This makes it necessary to construct special drill seeders for cotton, having devices (agitators) to overcome the resistance caused by the cohesion of the downy seeds to the sowing apparatus.

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The existing models of cotton seeders are not always successful in handling the sowing of dry downy seeds, but if the seed is moistened, causing mutual adhesion of the fibrils, of the fuzz, sowing performance of such seeders is satisfactory.

When seeds are received from the plant, each kolkhoz should organize the sorting to eliminate immature, shrunken [redacted] and diseased seed, and also the seed of different varieties mixed with the lot (the downless Kara-Chigit seed, the large seeds with white fuzz of Navrotskiy variety, etc). This work is entirely indispensable in growing the Shreder No. 1306 variety, since this is the variety prescribed for sowings during the next few years on all fields in the New Areas, and loss of its purity must be avoided.

THE IMPORTANCE OF SOAKING SEED

Practice in the basic cotton areas of Central Asia and Transcaucasus regrads soaking of cottonseed in water before sowing as an obligatory cultural method, aimed at increasing germinating capacity under field conditions, together with germinating force, and therefore also intended to accelerate germination and enhance productivity. Seed is not usually soaked in the unirrigated cotton growing of the United States.

With other field crops, soaking is practiced with seeds that swell only slowly and require large amounts of water, such as sugarbeet.

With market gardening of beans and other legumes that need relatively large amounts of water for seed swelling, presowing soaking is, similarly, often considered obligatory.

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Soaking gives the seeds the moisture they need for germination in a shorter time than is possible in the field, and thus results in more rapid germination. Pre-sowing soaking increased field germinating and germinating force in experiments at the Turkestan Selection and Breeding Station (F. M. Mauer "Some Morphological and Physiological Properties of Cottonseed and their Agricultural Significance" Cotton Library, vol. 7. Moscow, 1927), with seeding depth of 5 centimeters and high temperature: 29.9 degrees at the 4 centimeter depth.

	Germinating Capacity in Percent	Germinative Power in Days by Arnold's Method
Dry Seeds	68.8	6.4
Moistened Seeds	72.0	5.4

In the New Cotton Areas, pre-sowing moistening of seed sometimes proved superfluous, and frequently even gave unfavorable results.

The results obtained at the Taman' Zonal Station in 1931 indicate the possibility of cases of harmful effects from soaking.

The unfavorable effects of seed soaking are expressed, when plantings are early, in retardation of germination, increase in mortality and in the last analysis in reduction of yield. The number of days between planting and germination (25-41) is enough to justify the conclusion that when plantings are made in early April, conditions in the New Areas are unfavorable for germination. In the ensemble of factors necessary for rapid seedling emergence, the one which is most frequently absent in the New Areas is high temperature accompanied by ample spring watering in fields tilled at the proper time.

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EXPERIMENT WITH SEED SOAKING AT TAMAN'

Time of Planting	DRY SEEDS			SOAKED SEEDS		
	Days between sowing and germination	Rarification in percent	Yield of lint in tsentner per hectare	Days between sowing and germination	Rarification in percent	Yield of lint in tsentner per hectare
April 10	37	7	21.7	41	9	20.7
April 30	26	23	16.7	25	27	16.3
May 10	16	8	18.2	16	4	20.1

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If the seeds lie long in the earth, development of fungus and bacterial diseases is encouraged in both seeds and seedlings, and the depredations of pests of every kind are favored. Swollen and soaked seeds cannot germinate before dry seeds if planted early, on account of insufficient soil temperatures.

At the same time, even if the period between planting and germination is prolonged, the dry seeds have sufficient time to swell naturally in moist soil.

Soaked seeds have softened integuments and are more readily attacked by pests and diseases than dry seeds which swell gradually from the soil moisture. The frequently observed heavy mortality among plants from early plantings of moistened seeds is apparently due to this. Moistened seeds lose their germinative power during a long stay in soil insufficiently warmed through, resulting in the retardation of germination observed in such seeds. Matters are different when the weather at planting is already hot.

Such weather usually commences in the New Areas at the beginning of May. Most of the evidence from direct experiment is in favor of preliminary soaking of seed for relatively late planting in May.

In practice one must always be ready to solve a problem in a different way. If weather or soil conditions are different. In any case, [redacted] pre-planting soaking cannot be indiscriminately condemned for the New Areas as it is among American farmers. The Socialist production of cotton must take advantage of every opportunity to actively influence nature, whether its intervention affect the soil, the adult plant, or only the seed. If it becomes clear that under certain conditions

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soaking of seed is really a method of accelerating germination, then this method must be used. The following conclusions can be drawn from dozens of experiments carried out in 1930 and 1931 by sovkhozes, kolkhozes and scientific institutions in the New Areas.

In early April planting dry seeds must be used, since soil moisture is usually sufficient at this time for the natural swelling of the seeds, while soil temperature is still not high enough for rapid germination.

In May, planting with moderate soil moisture and stability of warm weather (over 15-16 degrees), it is better to use soaked seeds. This cannot be done in dried out soil, since such soil quickly wrings the water out of moist seeds. There have been cases when such seeds have germinated, only to perish shortly after in the dry soil.

These are of course only general indications, based on the usual "normal" spring weather. There may be cases in which it may be advantageous to use soaked seed at the end of April or, on the other hand, to dispense with soaking even at the beginning of May.

The one to decide th question in each individual case should be the agronomist working in the undertaking.

TECHNIQUE OF SEED SOAKING

The experiment institutes of Central Asia recommend soaking cottonseed for two days or longer in running water or water changed daily. Experiments on the length of soaking, carried out in the New Areas (Prikumsk Station and elsewhere) have established the possibility of limiting the period to a single day.

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Short soaking for 18-24 hours makes it unnecessary to change the water. It is best to have the temperature of the water no lower than 15-20 degrees, since swelling is faster in warm water.

The question of the possibility of using sea water for soaking is of interest to for areas located near the sea or to bitter saline liman. This possibility has been established by experiments at the Taman' station in 1931 as well as at numerous sovkhozes and kolkhozes. The following results were obtained with May 10 plantings at Taman':

	DATE OF GERMINATION	YIELD OF LINT IN TSENTNER PER HECTARE
Dry seed	26 May	18.2
Seed soaked in sea water	26 May	20.1
Seed soaked in fresh water	26 May	20.1

The weight of cottonseed is more than doubled after soaking owing to the absorption of water by the swollen seeds. Thus the normal rate of planting, in terms of dry seed weight, is doubled for soaked seed.

To avoid unnecessary transportation, the soaking of seed must in practice be done near the place of planting. Specially constructed tanks and pools and ponds are used for soaking. Cement silage pits or any convenient receptacle may be used, such as vats, barrels, etc.

It is sometimes done in sacks only half full of seed.

The sacks must be immersed in water with the aid of a swinging arm or bob. In general it must be done in such a way that all of the seed is immersed. Even at high temperatures and in spite of a certain amount of air retained by the mass of downy seed, germination does not occur on immersion. But there

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are enough seeds floating on the surface of the water in contact with air to have sprouts appear soon. There is no objection at all to planting seeds that have just started to sprout, but if the sprouts are more than 3-4 millimeters long, their survival is doubtful.

In contrast to many other plants, the cotton plant reacts very unfavorably if its young rootlets are exposed to the air, not to mention breakage of the sprouts during planting by drill seeder. The time between termination of soaking and planting must be reduced to a minimum and should not in any event exceed 2-4 hours. Cases are possible in which some of the soaked seed may remain unplanted. In all such cases the seeds must be spread out to dry in a thin layer. The dried seeds may then be soaked again and planted.

THE IMPORTANCE OF DELINTING SEED FOR PLANTING

Some research workers in natural conditions in tropical countries are of the opinion that fiber and fuzz serve the biological purpose of protecting the seeds from soiling, overheating, suffocation, etc. F. M. Mauer (Turkestan Plant Breeding Station) set up an experiment to confirm this opinion. It consisted of the protracted soaking for 7 days of seeds of cotton of different varieties, with different amounts of fuzz on the seeds. To create the worst conditions, the water used for soaking was not changed during the experiment. The results showed total loss of germinating capacity by the bald or fuzzless seeds, while 2.5 percent of the almost fuzzless seeds germinated, while the seeds with full fuzz covering still retained 30.5 percent of their germinating capacity.

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Measures for slowing down the swelling of cotton seeds in the soil are not wanted; on the contrary, the task of cultural practice is to create all conditions for most rapid germination. The less the amount of protective integument remaining on the seeds, the higher will be the germinating capacity and the germinative power. This is applicable of course only to measured environments with conditions favorable to rapid germination. Experiments at Tashkent show that removal of the seed cover results in the best and earliest germination.

Delinting -- or reginning -- of seed for planting, which produces an additional raw material for industry, is at the same time a desirable cultural practice. It was feared that the seed would be damaged by the delinting saw teeth, or overheated during the process. It was feared that the placenta would be broken off, and it was assumed that this would lead to rotting away of the seed in the ground. Parallel analyses of the condition of delinted and non-delinted seed showed the baselessness assumption of delinting damage to be unfounded. ("A Contribution to the Question of Delinting Cottonseed for Planting." Periodical Khlopkovoye Delo , No. 1 and 2, Moscow, 1925.) Thus there were in all 0.3 percent more of damaged seeds among delinted material than among non-delinted seed.

The Turkestan Experimental Plant Breeding Station (F.M. Mauer) furnishes convincing evidence in favor of delinting.

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EXPERIMENT WITH DELINTING AT TURKESTAN PLANT BREEDING STATION

	Dry Seeds		Soaked Seeds	
	Germination Capacity, In percent	Germinative power, In days	Germination Capacity, In percent	Germinative power In days
Undelinted seeds	81.5	5.9	85.5	5.6
Normally delinted seeds	89.5	5.3	83.5	4.8
Closely delinted seeds	82.0	5.5	87.0	4.7

Even close delinting increases the percentage of seeds germinating and enhances the germinative power.

Delinting of seed material should thus be considered a necessary procedure in preparation for planting in the New Cotton Areas. The agrotechnical significance of delinting should be especially great for the intermediate and late plantings at the end of April and the beginning of May.

Fuzz makes up about 12 percent of the weight of ginned seed on the average. The saw delinters at the spinning mill remove about 2 percent of this, leaving about 10 percent untouched.

DELINTING COTTONSEED

A considerable number of the many different forms of the cotton plant all over the world consist of varieties without fuzz, or only a small amount of it. Most of the commercial Egyptian varieties belong to this group.

Numerous experiments have shown that hairless seed[15] superior to downy seed in field germination capacity and in germinative power.

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Mechanical delinting of cottonseed cannot completely remove the fuzz and make the seed entirely bare.

Special delinting machines make it possible to remove up to 7-8 percent of seed weight in the form of additional lint and linters.

Since 1914 in America linters have been removed by use of the Ragodel machine. Since 1917, on demand of the War Department, the removal of linters has been compulsory. The best delinter -- the De Segundo defibrator -- takes off 5-6 percent of the fuzz.

If linters amounting to only 4 percent of seed weight had been taken off in 1931, the Union would have yielded 53,600 tons of pure cellulose (about 80 percent of linter weight).

The chemical methods of delinting being worked out on a pilot-plant scale at the present time are of great interest to agronomic technology.

Thus the fuzz was completely burned away by treatment with concentrated sulphuric acid. This method was proposed as early as 1911 by Mr. Diger (Alabama Agricultural Station, United States).

V. G. Blekmen (Professor Dr. V. G. Blekmen. Treatment of Cottonseed with Concentrated Sulphuric Acid. Khlopkovoyo Delo, No. 1, Moscow, 1929.) performed a large number of experiments with all possible varieties of cotton, and became convinced "that the treatment of cottonseed with concentrated sulphuric acid for 20-30 minutes followed by washing for 20 minutes in frequently changed water may be employed for delinting purposes without damage to the seed (in consequence of which ger-

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mination under field conditions proceeds earlier and in a uniform manner), and also for sterilizing the surface of the seed.

In our experiments there were cases in which seed remained in concentrated sulphuric acid (75.4 percent) as long as 12 hours, and sometimes up to 2 days, without perceptible reduction of the germination capacity of cotton variety No. 182. After delinting by Sulphuric acid careful and prolonged washing of the seed is absolutely necessary, preferably under running water.

Delinting may be accomplished by 20-30 minutes treatment with concentrated sulphuric acid of specific gravity 1.66 or higher. About 28 kilograms of acid is required to delint 100 kilograms of very downy seed. The linters removed are turned into glucose, which is then fermented to produce alcohol. 3 liters of alcohol may be distilled from the product of 100 kilograms of treated seed.

An even more attractive suggestion (A. P. Zakoshchivov, V. T. Ivanova and others. How to Utilize the By-products of the Cotton Culture of Central Asia. Journal "Za khlopkovuyu nezavisimost'", No. 6-7, Tashkent, 1931,) is to remove the linters from the seed by treating it with the fumes of hydrochloric acid. In this case the linters are obtained in powder form as hydrocellulose, which in turn may be converted into cellulose acetate and used in manufacturing artificial silk.

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EXPERIMENT WITH DELINTING

Forms of seed	Prikumsk		Khasav-Yurt		Remarks
	Yield of lint in tsentner per hectare	Percent of shedding	Yield of lint in tsentner per hectare	Percent of shedding	
Ordinary seed	9.8	56	5.7	29	Delinting at Prikumsk by treatment with strong sulphuric acid for 10 minutes; at Khasav-Yurt with hydrochloric acid of specific gravity 1.56 for 14 hours.
Delintered seed	10.9	36	9.3	50	

The possible practical significance of delinting may be illustrated by the following results of field experiments at Prikumsk and Khasav-Yurt in 1932.

V. Stets, (Plantings of Cottonseed Chemically Delinted by Strong Sulphuric Acid. Publications of SREDAZNIKhI, Tashkent, 1933.) presents the following results of a delinting experiment with sulphuric acid, performed in 1932 at the Ak-Kavak Station (Tashkent).

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	DAYS BETWEEN SOWING AND 50 percent GERMINATION	DENSITY OF STAND IN THOUSANDS OF PLANTS PER HECTARE
Delinated seed, soaked in water	5	93
Ordinary seed, soaked in water	7	58
Delinted seed, dry	5	101
Ordinary seed, dry	9	58

The earlier germination and greater field germination capacity speak in favor of delinting.

The experiments of the STAZRA of the SREDAZNIKhI on the Murgab sovkhozes (1931) and on the SOVKHOZ "Vakhsh" (1932) note sharp reduction in the incidence of gummosis in plants of Egyptian varieties grown from delinted seed. According to the observations of V. Stets, fuzzless seed after delinting possess the capacity of germinating at relatively low levels of soil moisture without preliminary soaking, which is explained by "the action of strong sulphuric acid on the tough seed coat, making it more permeable and assuring closer contact between the surfaces of delinted seeds and the capillary part of the soil."

The ability to obtain fuzzless seed opens up a series of vistas before the agricultural technology of cotton growing.

Earlier and uniform germination of all seeds sown may be awaited, and consequently a certain increase in productivity as well; it will be possible to use grain drills for sowing cottonseed, and these are technically far more perfected than the sepcialized cotton seeders.

And finally, we may also await a reduction in the fungus and bacterial diseases carried over with the seed.

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STIMULATION (BIONTIZATION) OF THE SEED.

The possibility of stimulating the growth and development of agricultural plants by single treatments of the seed with certain chemical compounds has been established practically by the Bulgarian Professor Popov. In 1923 he communicated the results of successful experiments by which the productivity of proso millet was increased as a result of soaking the seeds in 1 to 3 percent solutions of magnesium, manganese or sodium.

The control plants yielded 340 grams of seed while the experimental plants yielded up to 650 grams. A year later a German corporation was distributing patented stimulants ("Stimule" and other preparations).

As a result of the great research of Popov and other investigators, there is now a long list of substances capable of filling the role of stimulants [redacted] set up.

The list includes Mn, Na, Ca, Mg, Fe and their salts, As, K, alcohols, sugar, organic acids, carbon monoxide, carbonic acid, etc.

Popov asserts that only substances possessing reducing properties are able to give an impetus to the intensification of the processes of oxidation in the living cell, since retardation of the vital functions is due not to insufficiency of [redacted] oxygen but to a peculiar immobilization of it within the living molecule.

Dr. Spil'man, working in the Soviet Union, does not agree with the reduction theory of Popov and is inclined to explain the action of stimulators by a number of modifications in the colloidal properties of the plasma.

The new term "biontization" (stimulation) also belongs

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to Shpil'man. In any case there is still no clear theoretical explanation of the favorable effect of stimulation on plants. Whence the impossibility of explaining the cause of the indifferent and sometimes even negative effect of stimulators which has been observed by numerous investigators checking the experiments of Popov and Shpil'man.

According to Popov, the decisive factor in the action of any stimulator is the dosage of the preparation and the duration of its action on the seed. It is possible that the dosage may vary not only for different plants but also for different varieties and probably for different conditions of growth as well.

Magnesium chloride and manganese sulphate stood first in effectiveness, according to Popov's work.

In many cases treatment with formalin and tannin showed a good effect.

The Shpil'man laboratory has widely distributed its preparations, together with detailed instructions, among the sovkhozes and kolkhozes. The duration of soaking of cottonseed is different for different biontizators, for instance it is 24 hours for B.XV and 8 hours for B. 74. (Biontization of Seeds, a New Factor in Increasing Productivity. SEL'KHOZGIZ, Moscow, 1931). The laboratory has promised to prepare dry biontizators for sowing of dry seeds.

We present the composition of a few biontizators distributed throughout the New Areas.

B. XV_1 : mercuric chloride 12 grams, sodium chloride 6 grams

B. XV_4 : the same 0.086 gram eosine

B. 74 : chloroform 12 grams, ethyl alcohol 12 grams

B. 84 : mercuric chloride 12 grams, sodium sulphate 60 grams

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The contents of a package of a preparation sent from the laboratory are dissolved in boiling water, and a definite amount of cold water is added in accordance with the directions on the label.

The seeds are immersed in the solution for the time specified in the instructions.

Experimental checks of the effect of the Shpil'man biontizators have been made in the new cotton areas. In almost all of these experiments, no positive effect of the biontizators on growth and yield of the cotton plant could be noted.

The following determination of the existence of such an effect may be considered an exception.

	PRIKUMSK, 1931	SKALOVSK, 1933
	YIELD OF LINT BEFORE THE FIRST FROST	TOTAL YIELD
Biontizator XV_1	6.7	-
Biontizator XV_4	-	1.4
Control	5.4	0.7

At prikumsk acceleration of boll opening by three days was noted (October 15 instead of October 18).

The experiments were repeated a large number of times and the results obtained are not open to question.

These precisely determined facts of the positive effect of the biontizators, even though there are only two cases, compel our attention to this new method of increasing cotton yields.

In 1928 I. P. Saraknov worked at Prikumsk on stimulation of seed.

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In his experiments he succeeded in accelerating the germination of cotton and increasing its yield by soaking the seed for 2-3 hours in a 4 percent tannin solution. Under laboratory conditions he observed acceleration of germination in cottonseed previously soaked for 15 minutes in a 5-10 percent soda solution or for 30 minutes in a 15 percent hydrochloric acid. (I. P. Sarakhov. Cotton on the Terek River. Tashkent, 1929).

Dr. Shpil'man's laboratory also includes physical factors under the heading of biontizators, such as heating and cooling of the seed, action of ultraviolet and Roentgen rays, etc.

PLANTING TIME

In many cotton areas of [redacted] Tadzhikistan, planting commences at the beginning of April. In Fergana cotton is sown from April 10 to May 1. The middle of April is the usual time when mass planting of cotton in most of the Old Cotton Areas begins. In countries still further to the South, for instance Egypt, cotton is sown in March, and in Brazil even in December. In the New Cotton Areas mass plantings of cotton take place during the period from April 20 to May 10. The planting season has been gradually worked out by the practice of the young cotton growing economy and confirmed by the data of research institute. Within the limits of this planting season, earlier commencement and completion should be aimed at. The necessity for having plantings as early as possible is dictated by considerations of organizational nature and by the direct tasks of increasing the productivity of the cotton fields. In experiments involving variable planting times, the highest yields were ob-

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tained with plantings carried out toward the end of April.

Earlier fruiting and a higher percentage of pre-frost lint yield is usually observed with early plantings, and consequently also improved lint quality.

The time of onset of the principal phases of "Shreder" variety No. 1306 varied as follows in 1931 according to date of planting:

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PLANTING DATES AND PHASES OF DEVELOPMENT

Date of Planting	KHERSON Days from Planting to			TAMAN' Days from Planting to			PRIKUMSK Days from Planting to		
	Germination	Flowering	Maturation	Germination	Flowering	Maturation	Germination	Flowering	Maturation
April 20	29	85	131	27	97	145	25	97	151
April 30	20	76	130	22	88	138	20	89	143
May 10	14	70	124	17	78	128	16	79	135
May 20	6	62	130	7	66	115	9	70	125
May 30	4	59	130	6	63	118	--	--	--

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It is plain from these data that the number of days from planting to maturation is considerably greater with the later planting dates. Lengthening of this period is principally on account of the longer planting to germination period.

EARLY PLANTING AND MORTALITY

The interval between planting and germination is often very protracted when planting is early and is the negative side of such planting. Seeds in the ground have in fact greater chances of pest damage, for instance by the cotton-borer or to be afflicted by disease (root rot), if germination is long delayed.

A considerable mortality is frequently observed to as a result from early planting. In experiments on planting dates, the mortality was expressed by the following figures, showing percentage of stand at a given density.

DATE OF PLANTING	Kherson 1931	Taman' 1931	Prikumsk 1931	Prikumsk 1932
20/IV	29	28	19	52
30/IV	13	37	3	16
10/V	18	30	6	21

To prevent the mortality of early plantings, the rate of seeding may be somewhat increased, dry seeds planted, incrustation controlled at the proper time, and other measures of sound agronomic practice taken with respect to planting and management during planting. Early planting cannot be rejected on this ground, for in spite of a somewhat greater mortality, early plantings

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Under the conditions of the hotter climate of Central Asia and especially during the warmer and dryer autumn, Variety 169 is only 4-5 days later in onset of boll opening than "Shreder" 1306. In the New regions, however, the former variety not only is not infrequently 10 and even 20 days later, while flowering but almost simultaneously with 1306.

It should not be necessary to add that the New regions are regions of dry farming and it is necessary to hurry with plantings to avoid the danger of dessication of the upper soil layer in case of an arid spring.

EARLY PLANTINGS AND INCREASED PRODUCTIVITY

In most experiments in the New regions, the advantage remained with early plantings, both with respect to total and pre-frost harvest.

The following are the results of experiments with "Shreder" 1306 variety over a few years, at Kherson in the west and Prikumsk in the east of the cotton belt of the New regions.

PLANTING TIME AND YIELD

PLANTING TIME	PRIKUMSK						KHERSON			
	1931		1932		1933		1931		1932	
	I	II	I	II	I	II	I	II	I	II
10/IV	13,3	7,4	10,7	4,3	11,0	4,1	--	--	9,4	9,4
20/IV	13,4	7,8	14,1	6,5	10,7	4,4	14,5	7,8	10,2	10,2
30/IV	14,0	9,6	19,2	12,1	9,1	2,5	14,3	6,1	9,5	9,5
10/V	14,0	8,5	16,6	8,4	8,4	1,5	13,9	4,7	10,7	10,7
20/V	13,2	7,6	8,4	2,1	7,0	0,7	14,6	4,2	9,1	9,1
30/V	5,0	0,4	7,6	0,0	6,0	0,0	10,0	0,5	8,8	8,8

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Note: Yield is in tsentner per hectare, calculated from data for plots of about 200 square meters. Six repetitions in each case. 1: total crop. 11: pro-frost crop.

The data presented point to the correctness of the planting period prescribed and to the correctness of the general directive calling for earlier planting times within the limits of this period from April 20 to May 10. The best results are only infrequently produced by earlier plantings (for instance at Prikumsk in 1933) or by plantings after May 10 (Kerson, May 20, 1931).

PLANTING TIMES AND THE NEEDS

On sites badly overgrown with weeds, especially with malignant weeds (scutch grass, smartweed, thistles, etc), it is better to commence planting somewhat later, but not beyond May 10. This course is indicated by the data on the greater growth of weeds with early plantings, since weeds, being less exigent of water, commence to develop earlier than the cotton plant.

Thus at Kherson in 1932, on a planting of April 10, 55 different weeds were counted per square meter up to the moment of the first weeding, while on plantings of April 10, 20-21 and finally on plantings of April 30 to May 10, only 9-10 weeds per square meter were counted.

Data of the Taman' Zonal Station for 1933 point out the possibility of reducing the number of weeds to one quarter even where the soil is badly overgrown, by a pre-planting tillage, at the cost of some delay in planting.

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PLANTING TIME	[redacted] NUMBER OF WEEDS PER SQUARE METER BEFORE PRE-PLANTING TILLAGE	SAME BEFORE FIRST WEEDING
May 2	21	399
May 15	87	100

Within the limits of the planting season (April 20 to May 10) the most badly weed-infested plots should be planted last of all, and a good pre-planting tillage done immediately before planting.

INDICATIONS TO DETERMINE TIME FOR COMMENCING PLANTING

The New Cotton Regions are distinguished by their great territorial extent, and above all by the extremely great fluctuations of meteorological conditions during the year. Cases have been observed of maximum crops in individual years and individual regions from plantings even earlier than April 10 or even as late as May 15-20.

Earlier planting times are entirely practicable if stable warm weather has already set in at the beginning of April. It is risky and inadmissible to count on the success of plantings later than the latter half of May. The only exceptions may be for replantings after destruction of the sprouts by hail, torrential showers, etc. The definite time of commencing planting within the limits of the planting season is determined by weather and soil conditions.

The air temperature in spring is a poor guide for determining the optimum time for commencing the planting. Warm and even hot weather not infrequently sets in for a short time even during the first days of April, which might induce early planting. Excessive haste with starting planting in such cases usually leads to serious seedling mortality. As seeds and seedlings rot

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easily in soil which is still insufficiently warmed, especially when weather is followed by a long cool spell. The researches of NOVNIKhl (S. D. Lysogorov. "Fixing the time of Cotton Planting," in Ukrainian. "Za Radyan'sku Babovnu", No. 1-2, Kherson, 1932.) show that soil temperatures is far more reliable as a guide. It may well be that the temperature of the soil at planting level is the best guide. But the temperature of the surface layers of the soil closely reflects even short spells of warmer or cooler weather, and it is thus difficult to draw any conclusions on that basis alone as to the general increase of spring warmth. At a certain depth the rising curve of spring soil temperature is fairly flat and without significant fluctuations. Experience has shown that for the purpose of fixing the optimum planting time it is best to use the soil temperatures at a depth of 40-50 centimeters.

The graph on the next page shows the march of air and soil temperature, in juxtaposition with the yields for various planting times, using the mean of the values at a number of points: Taman', Prikumsk, and Khasav-Yurt, for 1931 and 1932.

Even in the means of its values the curve of soil temperature shows a more uniform rising trend than that of air temperature, which has both steep ascents and sharp dips. A considerable increase in air temperature is observed around April 10. Only continuing low soil temperature should dissuade cotton growers from commencing planting operations. Comparison with the data of mean yields for the various planting times shows that the April 10 plantings gave even lower yields than those of May 20.

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The graph on the next page shows the march of air and soil temperature, in juxtaposition with the yields for various planting times, using the mean of the values at a number of points: Taman', Prikumsk, and Khasav-Yurt, for 1931 and 1932.

Even in the means of its values the curve of soil temperature shows a more uniform rising trend than that of air temperature, which has both steep ascents and sharp dips. A considerable increase in air temperature is observed around April 10. Only continuing low soil temperature should dissuade cotton growers from commencing planting operations. Comparison with the data of mean yields for the various planting times shows that the April 10 plantings gave even lower yields than those of May 20.

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The optimum planting times with respect to yield (see graph) fell within the period when soil temperature reached 12 degrees at 40 centimeters depth. To place the planting season at the best time in any given year, it is necessary to be guided in commencing planting by the days when soil temperature reaches 10-12 degrees at a depth of 40-50 centimeters.

Soil temperature may serve as one of the objective guides for the time of initiating planting.

S. D. Lysogorov tried to make a comparison of the optimum planting times for cotton with phenological observation on living natural objects.

He thus determined that the flowering of lilacs under Kherson conditions commences most frequently at a time when soil temperature at the 50 centimeter level has attained 14 degrees.

In the same area, the cherry tree ordinarily commences to flower 1-3 days after soil temperature has reached 12 degrees at the same depth, and its flowering frequently concides with the moment when the optimum period for cotton planting begins.

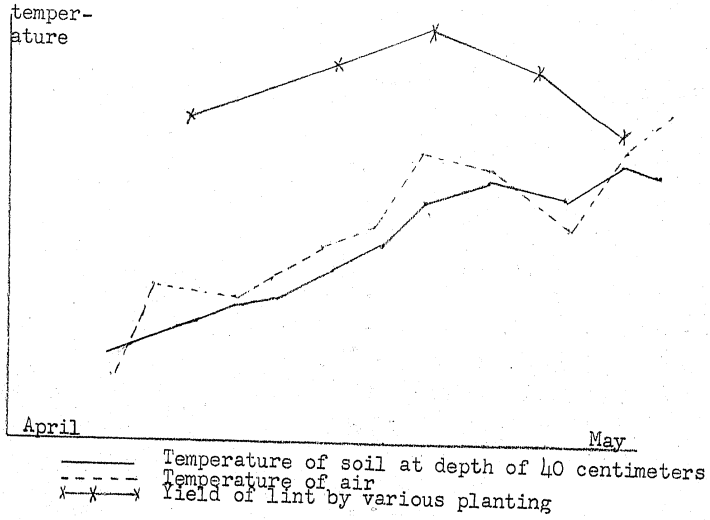

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Figure 23. Yield of cotton in new regions with relation to the temperature cycle of the air and the soil. (Data for 1931 and 1932)

One of the unfavorable features of late plantings is the danger of soil dessication in the event of May drought, which is possible in the New Areas.

The cotton plant requires only a negligible amount of soil moisture for germination, not exceeding 80-100 percent of the weight of the dry seed sown. Nevertheless soil moisture conditions should not be neglected, inasmuch as the upper horizons can become so dessicated during the relatively long interval between planting and germination of cotton that even this insignificant requirement cannot be satisfied.

The lower limit of soil moisture required for germination of seeds was found in experiments by Professor S. I. Bogdanov to be close to double the maximum hygroscopicity of the soil. He found that seeds germinated on sand with 0.5 percent of moisture, on kaolin with 34.5 percent, and finally, on loamy chernozem with 7.8 percent of moisture.

Planting must be started earlier on light soils than on heavy ones, since light soils dry through and warm through more quickly. On heavy soils, drying to the stage of"maturity" should be awaited, since otherwise long-term damage to soil structure may result from premature tillage. No damage to cotton seedlings from late spring frosts should be feared, since germination does not usually occur before the late frosts in such years.

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It is exceedingly necessary in spring to make full use of the forecasts of the Weather Bureau of the USSR and its local offices, so as to avoid having a prolonged cool spell during the planting of shortly thereafter.

PLANTING TIMES ACCORDING TO AREAS

The following differentiation of planting times is noted for the individual Cotton Areas. The earliest commencement dates (often before April 20) are possible in Dagestan and the Astrakhan Area of the Lower Volga Kray. In the cotton areas of the Ukraine, especially on the right bank of the Dnepr, planting may begin somewhat later than in the other areas, say around April 25. The Cotton Areas of the North Caucasus and Krimea occupy an intermediate position.

The Cotton District of the Azov-Black Sea Kray (Tempryukskiy, Anapskiy Rayons) plantings begin a little earlier than in the Prikumskiy, Vorontsovo-Aleksandrovskiy and Mozdokskiy Rayons of the North Caucasus Cotton District.

In the Crimea the seashore Rayons (Leninskiy and Feodosiyskiy) begin planting before the Rayons in the central part.

DEPTH OF SEEDING

Orchardists and market-gardeners consider a depth of double the seed thickness sufficient for planting in hotbeds. Danger of rapid dessication of the surface layer of the soil is the principal reason for seeding field crops at considerably greater depths.

In the New Cotton Areas, 4-6 centimeters is the usual seeding depth for cotton. In heavy soils, badly dressed and cloddy on account of having been tilled too late, growers may

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sometimes have recourse to deeper seeding at the 7-8 centimeter level. The experience of numerous sovkhozes and kolkhozes points to numerous cases of early mortality of plantings and sharp yield reduction resulting from deep seeding.

If the soil is dried through in depth, before planting, it is better to do shallow seeding in dry ground and count on the rain than to do deep seeding in quest of soil moisture. Even at depths of 9-12 centimeters, only a very small percentage of the seeds germinate even under the most favorable conditions.

Germination of cottonseed under favorable temperature and mosture conditions is relatively rapid and apparently unaffected by insufficiency of air, but cannot get along at the surface, largely because of exhaustion of the nutrient supplies in the seeds. Thin, small cotyledons with under-sized, elongated nodes below the cotyledons and very feeble, short roots are produced under such conditions. Many seedlings perish even after reaching daylight. Seedlings so grown become green only tardily and sometimes remain partially etiolated. All this of course leads to sharp reduction of yield.

The Taman' Zonal Station carried out an experiment in 1931 with single row plots with different seeding depths in its rather light chestnut chernozem.

The results clearly indicate the superiority of shallow seeding at 3-6 centimeters, resulting in the earliest germinations, reduced early mortality and correspondingly higher yields.

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These results were with manual planting. The same station conducted another analogous experiment in the same year with machine planting, using the "Oliver" drill seeder, at depths corresponding to settings of the regulator for shallowest, medium and deep seeding.

SEEDING DEPTH	YIELD IN TSENTNER PER HECTARE	SEEDLING MORTALITY IN PERCENT
shallow, 4.5 centimeters	15.1	0
medium, 7 "	11.2	30
deep, 9 "	5.9	51

These results point to yield reduction already at 7 centimeters and to a catastrophic drop in yield at a 9 centimeter seeding depth. Experiments in other years and at other points gave similar results.

In practice seeding depths between 4 and 6 centimeters are recommended for cotton, with the general aim being towards shallower depths. Deeper seeding may be done, in special cases, where the mechanical composition of the soil is a light or with relatively late plantings in a hot, arid pet period.

SEEDING TIME

Seeding Rate and Stand Density

The seeding rate for cottonseed should be sufficient to assure the desired density of stand.

For maximum yield in the New Areas, the best area of supply for a single cotton plant for maximum yield in the New Areas is 700-900 square centimeters, given machine cultivation between the

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Planting Depth in Centimeters	April 20 Planting			April 30 Planting			May 10 Planting		
	Days to Germination	Seedling Mortality in Percent	Yield in Tsentner per Hectare	Days to Germination	Seedling Mortality in Percent	Yield in Tsentner per Hectare	Days to Germination	Seedling Mortality in Percent	Yield in Tsentner per Hectare
3	27	28	26.6	14	17	30.7	14	12	26.2
6	26	40	22.6	12	17	28.2	15	17	21.2
9	29	75	11.5	19	43	19.6	17	30	19.1
12	28	87	6.5	21	75	9.0	20	60	11.5

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rows and hand seeding in the rows; representing approximately 110,000 to 150,000 plants per hectare.

In cross-plowing it is necessary to have the seedlings in a continuous band, since the machine will leave uniform intervals between perforations at the distance for which its controls are set, regardless of the degree of evenness of any particular part of the field. Consequently, when a satisfactory cotton seeder [redacted] for multiple planting becomes available, the seeding rate will be considerably reduced, but for the moment in continuous row planting it is necessary to be even more careful to have a continuous band of seedlings with machine drilling than in the case of hand perforation.

The need for assuring a stand of 150,000 plants per hectare is the point of reference for estimating the required rate of seeding.

Seeding rate should vary according to seed quality, soil, weather during the planting season, and the other conditions determining the percentage of germination in the field.

The more favorable the planting conditions, the better the preparation of the soil, the greater the germinative power and the germinating capacity of the seed, the less seed need be planted per unit area.

It is of course obvious that miscalculation must be avoided in fixing the different seeding rates, and that orientation on the availability of seed at the enterprise, based on receipts according to plan, is essential. The planned average seeding

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rate takes into account not only the all agrotechnical conditions but also other factors, of which the most important, in the New Areas, are the supply shortages of seed of early varieties.

Seeding Rates and Seed Quality

A germinating capacity of 85 percent and over is considered good for cottonseed, while if it is lower than 70 percent it cannot be used for seed and should be processed into oil. To illustrate the point, we present the following results of 1931 experiments at Taman' with the "Ak-dzhura" No. 182 variety.

Seeds of different germinating capacity were planted. The area of supply in the experiments was 70 X 20 centimeters, 70 centimeters between rows and 20 centimeters between the plants in a row. Planting was on April 24 at the rate of 50 kilograms per hectare.

GERMINATING CAPACITY UNDER VARYING CONDITIONS

Germinating capacity in thermostat, in percent	Germinating capacity in field, in percent	Difference	Percent of seedling mortality for the given area of supply
87.5	56.6	30.9	5
80.5	43.7	36.8	12
70.0	27.0	43.0	35
57.5	16.0	41.5	55
45.0	8.3	36.7	65
35.5	3.3	32.2	75

The experiment shows a great divergence between the values for germinating capacity determined in thermostats and the actual

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germinating capacity under field conditions, which was considerably lower than in the laboratory.

The seeding rate of 50 kilograms selected for the experiment barely assured even so relatively large an area of supply as 70 x 20 centimeters. The experiment established a relation of dependence between field germinating capacity and the laboratory indicia of seed quality and emphasized the complete unsuitability for planting of seeds with germinating capacity under 70 percent.

If it is necessary to plant seeds with germinating capacity under 85 percent, the seeding rate must be correspondingly increased, usually by 1 kilogram of seed for each percent by which germinating capacity is insufficient.

Seeding Rates and Soil

Planting rates should be lower on soils with light mechanical composition than on heavy soils, since light soils heat through better and give earlier germination and higher field germinating capacity.

On heavy cohesive soils the planting rate should be increased, also on account of the greater mechanical resistance offered by the soil to the passage of the seedlings and in consideration of the danger of incrustation of such soils.

The single sprouts of cotton are not in a position to pierce the incrustations of cohesive soils, but clusters of 5-8 seedlings are able to lift masses weighing up to 400-500 grams.

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Seeding Rates and Planting Times

The danger of incrustation and of production of seedlings enfeebled by disease and pests is greatest of all with early plantings. All the advantages of early plantings can be realized only if seedling mortality is also avoided.

Seedling mortality can be combated by an increased seeding rate. Seeding rate should be increased for plantings in early April and reduced for late May plantings.

Field Germinating Capacity and Seeding Rates

An experiment with different seeding rates was carried out in 1931 at the Skadovsk KhLOPKOSOVKhOZ in Ukraine. Planting was done on May 6, and seedlings appeared on May 23.

The correctness of increasing the estimated percentage of field germinating capacity according to the seeding rate will be noted. Less seed perishes when planted in thick clumps than if planted sparsely.

Seeding Rates and the Yield

Increasing the field germinating capacity, and increasing the number of seedlings guaranteed against seedling mortality are measures that cannot fail to affect the yield.

In 1931 the Dagestan Zonal Station at Khasav-Yurt made a study of the yield in an experiment with varying seeding rates.

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Seeding Rate in Kilograms per hectare	Yield of Lint in Tsentner per Hectare
32	11,7
40	14,6
50	15,1
70	15,7
80	14,8

Under the conditions of Spring, 1932, which was characterized in the cotton areas of the Ukraine by strong development of weeds, and great prevalence of root rot as a result of the high precipitation, the following yields were obtained in experiments with varying seeding rates without thinning.

Seeding Rate	Bases of the Zonal Station			Remarks
	Skadovsk	Berdyansk	Ochakov	
35	11,2	1,1	3,1	Planting at
50	11,5	0,9	2,2	end of April
65	10,7	1,3	3,2	and beginning
80	10,8	2,8	3,9	of May

These figures were obtained for plantings not followed by thinning. The differing yields principally reflect varying levels of cultural practice.

Under excellent cultural conditions, (Skadovsk Base) high yields were assured by as little as 35 kilograms of seed. Where the level of cultural practice was low (Berdyansk, Ochakov) the highest yield was obtained only by the highest seeding rate. Increasing the seeding rate to 70 kilograms is extremely desirable as a measure of insurance against possible conditions unfavorable to germination and the emergence of seedlings.

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Seeding Rate in Kilograms per Hectare	Number of seeds Planted in Thousands	Number of Seedlings Emerged in Thousands	Field Germinating Capacity in Percent	Excess number of Plants to a Unit Area of Supply 60 x 10 , in Thousands
35	350	112	33	- 55
50	500	217	43	+ 50
65	650	307	47	+ 140
80	800	445	56	+ 278
95	950	512	54	+ 348

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Increasing the planting rate is even more important for plantings with mechanized cross-cultivation, in which thinning is done by the mechanical work of cultivators on the rows of emerging seedlings.

In 1932 an experiment on large tracts at the Naurskaya KhLOPKOSOVKhOZ gave the following results. Machine thinning was done during mid-May. The cultivators were adjusted for 40 centimeter cuttings and to leave "bouqets" 30 centimeters long.

The lowest seedling mortality and the highest yield was obtained with a seeding rate between 60 and 80 kilograms. The length of the interval between planting and germination characterizes the extent to which conditions of planting are favorable. In the Old Cotton Areas seedlings emerged on the 6th or 7th day after planting, while in the New Areas they often took 18 to 20 days.

Seeding rate	Plants obtainer per clump	Percent of empty hills	Lint Yield in Tsentner per hectare
30	1,8	40	0,4
45	4,3	33	0,7
60	5,7	23	1,2
80	11,2	5	1,4

It must be admitted that the natural conditions in Spring are less favorable for the germination of cotton in the New Areas than in the Old, and therefore increased "insurance" rates of seeding are more necessary.

At the same time, change of varieties is being energetically pushed in the New Areas. Seed of the new, earlier and

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more productive varieties is still scarce, and here maximum frugality must be practiced.

The seeding rate of 50-60 kilograms accepted in the New Areas, undoubtedly looks like a relatively low figure, imposed by circumstances. At the same time the data on field germinating capacity point to an impermissibly low level of planting practice.

It is entirely feasible to make the planned rate of 50-60 kilograms adequate, if all agronomic requirements are strictly fulfilled with respect to seed quality, soil preparation, quality of seed drill work, etc.

Agronomic thinning should be directed in the future towards still further increase in the coefficient of utilization of seed planted, i. e. toward the further reduction of the seeding rate. In fact, even with a seeding rate as low as 50 kilograms, almost four times as many seeds are planted as plants are desired in the field.

It is the task of agronomy during the next few years to reduce this spread. Solution of this problem will give the socialist economy thousands of tsentner of cottonseed for the oil pressing industry.

COTTON PLANTING METHODS IN THE NEW AREAS

Row Planting and Broadcast Planting

Broadcast cotton planting was prevalent up to recent times

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in Central Asia and Transcaucasia.

It has now been almost universally replaced by the cotton row drill.

The advantages of row machine planting are the uniform distribution of seed over the site, more uniform depth of seeding, and, most important of all, the possibility of mechanizing weed control. In the New Cotton Areas, row planting is used exclusively.

Cotton Drills in the New Areas

In 1928 a group of the well-known Banner single-row seed drills was brought into the New Cotton Areas. During 1929 and 1930 single-row Oliver and McCormack seed drills were also acquired. With the development of cotton growing in the New Areas, the cotton drill manufacturing industry acquired the "Armalit" plant in Armavir city.

In 1930, "Armalit" began to put out two-row seed drills of McCormack type, and in 1932 it met the demand of kolkhozes and sovkhozes for a high-production, wide-range implement by turning out a small batch of five-row seed drills (with six boots available for use with an inter-row distance of 60 centimeters).

From the very first years of commercial cotton growing, the kolkhozes of the New Areas began to use single-row-seed drills in tandems and coupled groups, even with horse traction.

Regular seeding is demanded above all from a cotton drill.

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Regular seeding and uniform depth is necessary to obtain simultaneous germination of all seed. The shoe and colter must place the seed in damp earth with minimum displacement of the soil layers, so as to protect the seed locations from drying out.

The runner-type shoe of the Oliver seed drill gives good placement of the seed, but its tractive resistance is great in comparison to the disc shoe. The runner-type shoe pushes away the earth and makes an even, flat furrow bottom, in which the seed is lodged in damp soil at uniform levels.

At the same time the single-disc shoes of the Armalit seed drill have many faults. They pile up the earth and form deep furrows in the damp soil, so that early inter-row cultivation is impracticable.

On land badly overgrown with weeds the space between disc and shoe becomes clogged up with root material and piled up earth. And finally, the Armalit seed drill with single-disc shoe places the seed at two different levels, since the furrows are terraced owing to faults of the shoe design. It is possible and desirable to substitute the two-disc shoe from the grain drills for the single-disc shoe on all Armalit seed drills now in service.

One of the principal advantages of the "VIM Star" universal seeder-cultivator constructed by the Mechanization Department

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of NOVNIKhl is that it has two-disc shoes which are free from the faults mentioned above and work satisfactorily on weed-infested soils.

This seeder is a 24-row grain drill, model T-7, of the "Krasnaya Zvezda" plant. Parts of a cotton seed drill can be mounted on its chassis, or parts of cultivators may be used by means of complete substitution of the operating mechanism. This seed drill is adjustable to six-shoe operation for cotton planting. Besides its great achievement; universality, the "VIM Star" has a compartment for an extra seed supply for 3 kilometers of planting distance, (in addition to the planting tanks of the Armalit seed drill) and automatically raises and lowers markers.

The "VIM Star" seed drill has already been tried out in practice in sovkhozes, and the "Krasniya Zvezda" plant("Zinovievsky city, Ukrainian SSR) is at present producing it.

Coupled Seed Drill Operation and Productivity

Operation of coupled or multi-tandem seed drills economizes labor and better preserves the uniform distance between seeding rows. The single-row seed drill needs 2 workers and one horse. The two-row drill needs, if horse-drawn, 2 horses and one worker. Coupled operation of 4-5 single row drills, horse drawn, needs only 3-5 men instead of 8-19. Using a tractor, coupled operation of 8-12 single-row or 4-6 two-row drills needs 5-7 men, including the tractor crew.

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The coupling consists of a cross-bar and frame on wheels, to which a shaft is attached in the center. The seed drills are attached to the frame at distances of 70 centimeters by swivelled clamps. Four single-row seed drills are usually employed in coupling with a team of four horses. The drills can be fastened firmly together in pairs, which in turn are attached by hooks so that each drill can respond to irregularities of the relief. The driver's seat is attached to the middle of the frame.

Tractor trailers are constructed in the same way, but the frame is enlarged accordingly, and a longitudinal cross-bar with trailer link is substituted for the shaft. The plant was developed a special trailer for coupling two-row Armalit drills. The seeding capacity of a tractor-drawn group of four coupled two-row Armalit drills can seed 24 hectares a day, while a group of six such drills can handle 36 hectares. The five-row Armalit drill seeds 22 hectares, and two take care of 38 hectares, all during the daylight hours of a single day.

Two "VIM Star" seed drills with a STZ tractor plants about 45 hectares, while single-row seed drills drawn by tractor plants about 2.6 hectare per day per single shoe.

Seed Drill Adjustment to Seeding Rate

Tests of cotton seed drills for accuracy of planting according to the established seeding rate may be made by weighing the amount of seed dropped on a tarpaulin during a definite number of wheel revolutions.

The two-row Armalit seed drill has a planting width of 1.4 meters and a walking wheel of 2.45 meters in circumference.

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This drill covers an area of about 50 square meters every ten revolutions of the wheel. The five-row Armalit drill has a planting width of 3.5 meters and a wheel circumference of 3.77 meters.

This drill covers about 200 square meters every 15 wheel revolutions. It is better to check the drill by the number of seeds dropped by it during a tour of a definite distance on the courtyard. With a weight of 100 grams per thousand seeds and a seeding a rate of 55 kilograms, 38 seeds should be planted for each linear meter traversed, with rows 70 centimeters apart.

The planting rate is regulated by moving adjustible slides or changing the gear ratio. During its initial operation it is essential to check the accuracy of planting by calculating the amount of seed dropped during a measured course from a perfectly dry seed reservoir. The basket of the seed drill produced by the Armalit plant holds about 5 kilograms of dry seed, or about 2.5 kilograms of soaked seed on a dry seed basis. With a seeding rate of 55 kilograms, a full basket of dry seed should last for about 1300 linear meters of running.

All the seeder drills of a planting aggregate should be adjusted to operate at the same seeding rate and seeding depth.

Rolling the Planted Ground

Almost all cotton seed drills have rollers behind the shoes to roll down the planting furrows, or the plantings are rolled down by walking wheels with special rollers. In the arid New Cotton Areas, rolling assures the upward movement of moisture from lower soil layers to the seed. Rolling is also not

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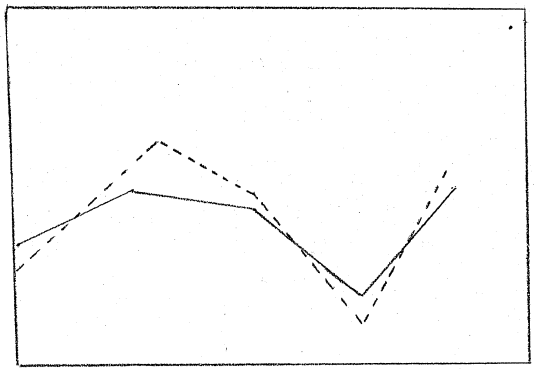
indifferent for the thermal regimen of the soil.

In the graph presented below the diurnal march of temperature is compared in loose soil and lightly packed soil, from data of 1933 of observations at Prikumsk.



_____ Loose soil

---------- Packed soil

Fig. 25 Diurnal change of temperature in loose and packed soils

It will be seen from the graph that packed soil accumulates more heat than loose soil during the daytime hours. At the same time it also loses more heat by radiation during the night.

Temperature fluctuations are sharper during the course of the day in the packed soil.

At the same time the temperature rise during the daytime

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hours is greater in comparison to the loose soil than the drop during the night hours. The thermal regimen of packed soil is apparently more favorable than that of loose soil for germination of cotton seed. Seedling emergence is usually earlier and more [redacted] simultaneous on rolled plantings.

Pralinage

The presence of fuzz is the major obstacle which forces the use of special seed drills for planting cotton, which are technically considerably inferior to grain drills. Cotton drills do not usually do a satisfactory job on planting dry and poorly delinted seed.

The fundamental solution of the problem will obviously be found in complete delinting of the seed for planting.

The so-called pralinage is sometimes used as a provisional measure to alleviate the negative qualities of downy seed. This operation consists of rubbing the soaked or merely moistened seed with some hygroscopic substance: fine dry sand, ashes, seedcake meal, etc.

It is performed either by hand or in pralinage machines, [redacted] hollow revolving drums filled with seed and the pralinating substance. The treated seed becomes loose and flows freely, so that it can be more evenly planted by seed drills and is also easier to handle for seed sorting machines.

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Multiple Planting

During the subsequent management of the cotton field, not less than half of the emerging seedlings are removed during the first thinning. The question of the advisability of hill checking of cotton to reduce the expense of this operation and economize seed has arisen. Hill check should also assure a higher field germinating capacity, since the joint force exerted by a number of closely spaced sprouting seeds can easily overcome soil resistance; and this is especially important for heavy soils which form incrustations after rain. The practical application of the idea of multiple planting of cotton meets with difficulty in the shape of the extremely imperfect functioning of the existing models of hill check planters (De-Fur planter etc.).

A special attachment to the cotton drill for multiple square planting has been developed by the agronomist Soshal'skiy (Akimovsk Machine Testing Station of the Ukrainian SSR).

It consists of a slide with a lever and spring to close the shoe, and a rod to open the slide at fixed intervals of distance covered by the machine.

To do multiple planting with this method the field must be marked off in the furrows, with markings at right angles to the future rows. Furrows are plowed 10 centimeters deep and 17 centimeters wide. Planting is done across the furrows. The closed slide on the shoe cannot discharge seed, but when the rod on the wheel meets the furrow marker, all the slides are opened and drop the seed, and are then closed again by the spring until the next furrow is reached.

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This method of planting can only be tried on soils that are free from weeds, well broken and free of surface clods. It has proven to be incorrect under operational conditions.

Strip Planting

Many experiment institutes in both the Old and New Areas have studied the possibility of strip planting of cotton to attain maximum planting density and maintain wide spacing of the rows.

Under the conditions of small test plots with manual management during the planting, strip planting in 2 and 2 lines gives considerably higher lint yields, like any other method of planting at greater density. It is impossible to introduce this method into large-scale cotton growing, due to the development of weeds in the lines, which would entail heavy expenditures for

[continued on next Page]

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elimination in 20 or 30 centimeter lines.

The Importance of Straight-Line Planting

The necessity of having the rows [redacted] exactly parallel is one of the fundamental conditions of [redacted] correct planting. This facilitates placing the markers with the first alignment, and better still with the second alignment. Only when the rows are true and even, is mechanized handling of the cotton plant possible, using the full spread of the tillage implements [redacted]. The lay-out of the strips for planting should be a small ratio to the width of the planter's reach.

Night planting by tractor planters is impermissible.

Direction of the Rows

Orientation of the rows from west to east is desirable to assure maximum access of direct sunlight to the plants. The other factors determined by local conditions, must, however also be considered. For instance, an experiment at the Naurskaya KhLOPKOSOVKOZ (North Caucasus) gave the following results in 1931:

DIRECTION OF ROWS	YIELD OF LINT IN THE ROWS
North to South	1578
West to East	1467

In that particular area it is better to orient the rows from north to south, since the prevailing winds are from the east and this direction makes better snow retention possible when the stalks are left to stand during the winter, which is

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especially important in arid areas. In localities with dissected relief the rows must be arranged not along the slopes but perpendicular to them, since this direction helps to retain the summer rains. Field layout often decides row direction.

The Kruttsov Hole-Planting Method

The agronomist Kruttsov, pioneer of the transplanting method of cotton growing, has proposed a new technique of planting, (Kruttsov, A New Method of Planting Cotton. "Za Khlopkovuyu Nezavisimost'", No. 6-7, Tashkent, 1931), which permits very early planting, for instance in the first days of April or at the end of March. Conical holes, 10-13 centimeters deep, with diameter of 4-5 centimeters at the top and 0.5 centimeter at the bottom, are made in a harrowed field. Cotton seeds are planted in these holes, which are then covered by pieces of glass slightly larger in diameter than the top of the holes.

Kruttsov performed an experiment with this method of planting near Tashkent in 1931. Planting was done on April 5, and the seedlings emerged on April 17. The American variety began to bud on June 4, while the Egyptian "Pima" variety followed on June 10.

Such "individual cold hothouses" are not inferior to transplantation culture in speed of plant development. According to Kruttsov's observations, this round-hole method of planting can withstand late spring frosts down to 10 degrees. However, its use in the New Areas has not proved justified, as the sides of

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the holes slide and the holes fill with mud after every rain.

Density of Stand

It is almost the primary task of agronomy in the New Areas during the next few years to protect planted cotton from weeds. In view of the exceptionally weedy condition of the fields which is the heritage of individual peasant farming, cotton can be grown in the New Areas only as a tilled crop. Experience has shown that weeding merely between the rows is not enough, since the weeds growing in the rows themselves, between the plants, smother the seedlings just the same. Whence follows the need for having recourse to weeding in the rows between the plants. This measure is completely obligatory, especially during the initial stages of plant development, when growth is slow and suffocation by weeds easy.

In the New Areas tractor and horse plowing is employed only for cultivating the spaces between the rows, while all the weeding in the rows and sometimes between the rows as well is done by hand hoeing.

In 1931, the agronomist S. T. Kosenko used large-scale mechanized cross-cultivation of cotton fields for the first time, at the Bugassk KhLOPKOSOVKhOZ on the Taman'. The mechanization of chopping and weeding in the rows by crosswise cultivation made "clump" arrangement of the plants on the site necessary. At the present time, there are three basic types of plant arrangement, which depend largely on the degree of mechanization of weeding work.

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First Type: Location of Plants in the Field for Hand-Weeding in the Rows

With rows spaced 70 centimeters apart, distance between plants in the rows must be 10-20 centimeters.

The necessity of closer spacing in the rows was first realized in the cotton areas of the Ukraine, where this space was fixed at 10 centimeters as early as 1931. In the New Cotton Areas of the RSFSR, in 1930 and 1931, a 20 centimeter spacing between plants was recommended. In 1932 there was a shift towards closer spacing at 10-15 centimeters, and in 1933 the agricultural regulations fixed the distance at 10 centimeters.

Second Type: Locating the Plants for Mechanized Chopping

Use of tractor-cultivators "Aksay" No. 8 and "VIM" No. 1 for mechanized chopping and sometimes simultaneously for the first weeding in the rows as well commenced in 1932, while special sc choppers constructed by the Kolkhoz workers and inventors Dolgopolov, Minayev, and others, were also used.

After mechanized chopping, "clumps" 15-20 centimeters wide remain, with 2-3 plants in each clump. Chopping is done in such a manner as to leave a space of 15 centimeters between clumps. [redacted]. The narrow passages, only 15 centimeters wide, between the clumps cannot be gone over again with the cultivator. Therefore subsequent weedings between the plants in the rows must be done with the hoe alone.

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Third Type: Locating Plants for Mechanized Cross Cultivation

Mechanization of subsequent weeding operations by using cross cultivation requires wide spacing of the clumps for the possibility that a second run will be necessary by the cultivator. So as not to reduce the number of plants too much with such a distribution of clumps, five plants should be left in each clump, with length of clumps 25-28 centimeters.

The layout of plants for the different types of cultivation may be seen from the diagram in Figure 26.

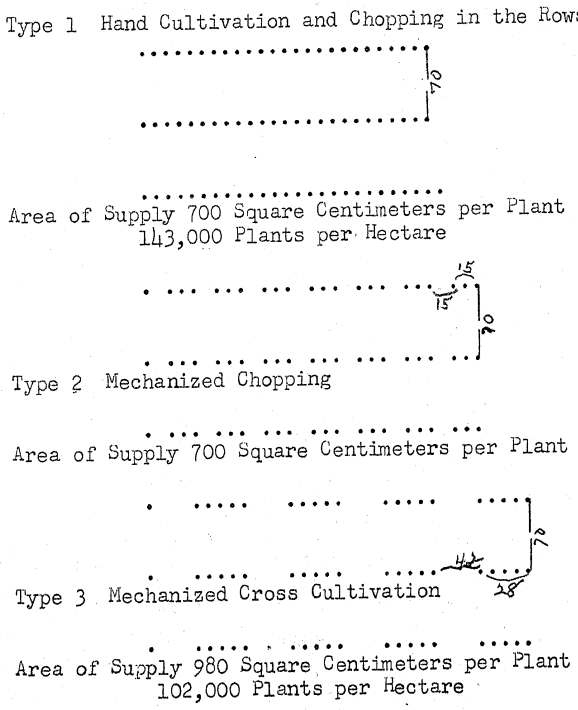

Fig. 26. Layout of cotton plant distribution for different forms of cultivation between rows.

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Planting Density and Lint Yield

Almost all the research institutions of both Old and New Cotton Areas have studied the question of area of supply of the cotton plant.

The most complete and detailed work on the subject, in Central Asia, has been done by the former Turkestan Agricultural Experiment Station and the Ak-Kavak Station (work by R.R. Shreder, N. N. Balashev, and A. F. Makarov).

Numerous experiments have established the considerable increase of yield that results from close spacing. In the United States there were extensive experiments on density of stand, mostly in the years after the First World War. In almost all of them the densest planting gave the highest yields.

The results of the experiments at Golodnoy Steppe (M.M. Bushuyev), Ashkhabad (P. A. Kozik), Gandzhe (I. S. Varuntsyan) and others lead to analogous conclusions. The absence of any limit to the increase of yield with increasing density of spacing is characteristic for almost all experiments. Only in isolated instances, where stands of over 150,000 to 200,000 plants per hectare were under study, was a certain reduction in yield noted. In 1926, in the New Cotton Areas, at Kherson, [P. I. Podgorniy. Report on Activities of Kherson Agricultural Experiment Station During 1925-26. Kherson City] obtained the maximum yield with a single irrigation from a spacing of 65x20. Higher densities

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than this were not tried in the experiment. In 1927, V. G. Rotmistrov /Experiments with New Crops During 1927/ obtained the maximum yield with the "extreme" density represented by 44x34 centimeters (at Dornburg, Melitopol' area).

1931 was a year of abundant warmth and rainfall, and record lint yields - up to the equivalent of 20 tsentner per hectare - were obtained for the most densely spaced plantings.

Area of Supply	Plants per Hill	Thousand Plants per Hectare	Prikumsk	Kherson	Taman'	Khasav-Yurt
60 X 10	1	166	19,1	20,6	21,6	16,4
60 X 20	1	84	15,3	19,2	21,6	15,6
60 X 30	1	56	14,0	16,1	19,2	13,3
60 X 40	1	42	10,2	15,6	18,0	11,0

Note: Yields are in tsentner per hectare. Variety No. 1306.

Meteorological conditions in the New Areas vary greatly from year to year. There is the natural danger of getting altogether different results in less favorable years. In 1928 at Odessa "the yields from 30 x 10 and 30 x 20 centimeter spacings were outstanding both in total weight and especially in weight of lint picked before the frost." This conclusion by /G. M. Moskalenko, Density of Stand of Cotton under Unirrigated Conditions of the Odessa Region. Odessa, 1930/ was drawn under conditions of an unproductive, cold and damp season, when frequent cold spells and heavy rainfall, especially in June and October, forced doubt of the possibility of the bolls opening at all before the frost."

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In cold, damp years close spacing sharply increased the yield also according to the results of the Kuban (Krasnodar) and Kherson stations. The danger still remains that in the arid years close spacing may not justify the hopes pinned on it. In 1929, when "the cotton fields were oases in a desert burned up by the sun" /Ya.Ye. Penzin, A Short Account of the Experiments With Cotton In the North Caucasus and the Crimea During the 1929 Season. Tashkent, 1930/ the maximum yield on the Taman' was obtained with a stand of 178,000 plants per hectare, and at Kerch with a stand of 230,000 plants. In 1930, which was unfavorable for cotton growing both because of its aridity and its lack of the usual amount of heat, close spacing also proved to be a measure that enhanced yield.

In 1930 almost all tilled crops perished in the extremely arid Prikumskiy Rayon of North Caucasus, and cotton was the only crop to cope relatively well with the drought.

The Prikumsk Cotton Station has furnished the following data for 1930:

Area of Supply	Thousand Plants per Hectare	Lint Yield in Tsentner per Hectare	
		Variety 1306	Variety 182
20 x 20	250	3.4	1.9
40 x 20	125	3.6	2.3
60 x 20	83	2.6	1.3

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Another example is from the work of the Dagestan Station for 1930 (Khasav-Yurt) "when the plants were somewhat dried even in the normal spacings, and on the closely spaced plots - 45x5, etc, had shed all their leaves by the time of maturation". /N. T. Prytkov, Agronomic Report of Dagestan Cotton Station for 1930. (Manuscript). It may be that in this case of drought, when the demands of the closely spaced plants for water made themselves felt, a fall in the yield should have been observed to result from close spacing. The figures on yield are to give the reverse effect.

VARIETY No. 1306

Area of Supply	Thousand Plants Per Hectare	Lint Yield in Tsentner per Hectare
90 X 25	42	3,5
60 X 20	83,5	12,1
60 X 10	166,5	13,7
50 X 10	200	13,9
40 X 10	250	13,6
45 X 5	444	9,3

The yield only dropped at 444,000 plants to the hectare.

In 1930, which was arid and unfavorable for cotton growing, the Naurskaya KhLOPKOSOVKhOZ obtained its maximum yield at 83,000 plants per hectare (60 x 20).

In 1931, the highest yield in the same sovkhozes - 19 tsentner

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per hectare - was obtained with the densest stand - 165,000 plants per hectare (60 x 10).

In 1932 the Zonal Station of Novnikhl produced the following results in an experiment with different densities of stand. Yield is reduced to tsentner per hectare.

Area of Supply	Number of Plants Per Hill	Taman'	Prikumsk	Kherson	Skadovsk
70 X 5	1	19,9	32,3	16,0	10,1
70 X 10	1	19,6	26,3	13,2	6,6
70 X 20	1	18,6	19,0	11,3	4,4
70 X 20	2	-	20,7	12,3	6,4
70 X 30	1	-	-	10,1	3,7
70 X 30	2	-	19,0	9,9	5,2
70 X 30	3	-	17,9	11,6	5,9

In 1932 in the Ukraine (Kherson and Skadovsk) the highest yields were obtained from close spacing, in spite of the aridity of the second half of the growing season, which caused the cotton plants to wilt long before the first frost.

The examples presented are enough to justify the general conclusion that a uniform dense stand of cotton in all parts of the New Cotton Areas are still forced by weed conditions to cultivate cotton as a tilled crop, it will hardly be expedient to narrow the spacing between the rows to less than 70-60 centimeters. As for closer spacing in the rows, it is obviously necessary

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to bring the distance between plants down to 16 centimeters, or if it is 20 centimeters, to have not less than two plants in every hill.

The Density of Planting With the "Clump" Method of Cotton Growing

There is still very little experimental material on which to base any judgment as to the optimum method of distributing plants for cross-cultivation. In 1931, Novnikhl carried out a series of experiments at its Zonal Stations with a square area of supply and different numbers of plants to the hill. Conditions with respect to area of supply are more severe for plants in a hill than for those in a "clump" which is drawn out to 20-30 centimeters in length.

The experiments in the Prikumsk and Taman' areas gave the following results.

Area of Supply, Variety 1306	Number of Plants Per Hill	Thousands of Plants Per Hectare	Prikumsk Lint Yield in Tsentner Per Hectare	Taman' Lint Yield in Tsentner Per Hectare
(1)	(2)	(3)	(4)	(5)
30 X 30	1	111	23,1	23,5
	2	222	24,3	23,1
	3	333	28,4	25,0
40 X 40	1	62	-	18,1
	2	125	-	20,1
	3	188	-	21,0
50 X 50	1	40	17,4	18,1
	2	80	19,4	19,0
	3	120	20,7	21,0
60 X 60	1	28	-	14,5
	2	55	-	17,9
	3	83	-	17,9
70 X 70	1	20	11,3	12,1
	2	41	12,9	14,7
	3	61	14,4	15,2

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It is striking that the highest yields in 1931 should have been obtained with the most closely spaced almost "solid" planting, with areas of supply 30 x 30 centimeters to the hill and three plants in each hill.

The conclusion may be drawn from the data presented that it is entirely practicable to alleviate the harm from the large area of supply required by cross-cultivation by increasing the number of plants to the hill, and with even greater reason, the number to the clump.

The following results were obtained in 1932 by the Ukrainian Zonal Station from its experiments on cross-cultivation with horse plowing. (Lint yield is in tsentner per hectare).

YIELD AND THE AREA OF SUPPLY

Area of Supply	Number of Plants Per Clump	KHERSON Total Yield	KHERSON Pre-Frost Yield	SKADOVSK Total Yield	SKADOVSK Pre-Frost Yield	BASHTANKA Total Yield	BASHTANKA Pre-Frost Yield
60 X 10	1	15,6	15,6	11,2	9,9	4,0	2,3
60 X 60	3	11,2	11,2	9,2	7,9	3,6	2,3
60 X 60	5	14,0	14,0	10,5	9,2	4,1	2,6
70 X 70	3	10,5	10,5	9,2	7,6	4,5	3,2
70 X 70	5	12,1	12,1	9,9	8,1	5,7	4,3
90 X 90	3	8,9	8,9	7,3	6,1	4,1	2,8
90 X 90	5	9,8	9,8	8,3	6,8	4,7	3,2

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In these experiments the width of the transverse row spacing remained the same as that of the longitudinal spacing (60, 70 and 90 centimeters). The length of the "clumps" remaining fluctuated between 20 and 30 centimeters. The results indicate the entire feasibility of arranging the plants in the field in closely spaced clumps at distances of 80-70 centimeters between clumps, almost without lowering yield.

The experiments point to the expediency of leaving 5 plants to a clump. In this way the effort to attain a denser stand of cotton plants will not be inconsistent with the widest development of mechanized weeding operations.

In 1932 the Prikumsk Station tried varying lengths of clumps and varying the spacing between them in two special experiments. Row spacing was 70 centimeters. Variety No. 182 was used. Thinning was done by the horse-drawn "Ukrainka" scraper.

YIELD AND "CLUMP" LENGTH

First Experiment

Length of Clump	Space Between Clumps	Number of Plants In Clump	Total Lint Yield in Tsentner Per Hectare	Percent of Total Yield Picked Before First Frost
15	45	1--2	11,1	7
25	45	2--3	12,5	8
35	45	3--4	13,0	9
45	45	4--5	12,2	10

Second Experiment

30	15	3	12,5	12
30	25	3	12,4	12
30	35	3	12,5	9
30	45	3	11,8	8

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The results of these experiments indicate the possibility of obtaining high yields by "clumping" (see above table).

They emphasize the accuracy of the space of 42-45 centimeters between clumps which is recommended in the New Areas with a clump length of 25-28 centimeters and with 5 plants to the clump.

Planting Density and the Development of the Cotton Plant

Central Asian and Transcaucasian experiments have established a slowing down of the basic phases of cotton plant development under the influence of closer spacing. For example, the Khorezm Experiment Station obtained the following results in 1928. /P. A. Yakhtenfeld. Experiments With Planting Density of Cotton in 1928. Izvestiya Khorezmskoy S.-KH. OP. Stantsil. YYP.5, Tashkent, 1930./

Area of Supply Per Hill	Number of Plants To a Hill	Interval in Days Between Planting and Flowering	Maturation
75 X 30	1	79	130
-	2	80	133
-	3	82	138
-	4	84	138

In the New Cotton Areas, the experimental data on this question is contradictory. A considerable number of the experiments(by G. M. Moskalenko, /T. F. Antropov, Experiments With the Cotton Plant at the Kuban Agricultural Experiment Station. "Khlopkovoye Delo", No. 7-8, 1930/ and others) indicate earlier

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flowering and earlier opening of the bolls with closely spaced plantings. Experiments of Novnikhi in 1931 yielded opposite results.

SOWING DENSITY AND DEVELOPMENT TIMES

Area of Supply for Each Plant	Number of Plants To The Hill	Interval in Days Between Planting and PRILUMSK Flowering	PRILUMSK Maturation	TAMAN' Flowering	TAMAN' Maturation	KHERSON Flowering	KHERSON Maturation
30 X 30	1	91	151	88	137	77	128
	2	89	146	88	137	79	135
-	3	88	149	89	139	80	139
50 X 50	1	92	153	89	137	76	127
	2	91	152	89	138	78	131
-	3	91	153	89	138	78	134
70 X 70	1	93	157	91	140	78	127
(for Kherson, 60 X 60)	2	93	155	91	139	78	132
	3	90	155	90	137	80	136

At Prikumsk, close spacing accelerated the appearance of flowers by 2-3 days and especially accelerated the opening of the bolls. Thus with a 30 x 30 area of supply, 50 percent of the bolls were open on the 151st day after planting, with a 50 x 50 area of supply, on the 153rd day, and with a 70 x 70 area of supply, on the 157th day. The onset of the phases is less strikingly accelerated by increasing the number of plants to a hill.

On the Taman' a tendency is noted for the onset of flowering and maturation to be accelerated by reduction of the area of supply, while on the other hand, except where the area of supply is 70 x 70 centimeters, development is retarded.

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At Kherson, the onset of flowering and maturation is delayed when spacing is close.

There is still no well-motivated explanation of the difference in the speed of development with closely spaced plantings in different years and different points. The effect of soil qualities should not be used to explain it, since under the influence of close spacing cotton plant development at the identical point is accelerated in some years and retarded in others. For instance, on the Taman', acceleration of the development of closely spaced plantings was observed in 1931, while in 1932 it was retarded. At Prikumsk it was accelerated in 1931 and retarded in 1933, etc.

In 1928 the Azerbaydzhan Station (I. S. Varuntsyan) tabulated the height of the first sympodial node in experiments on density of planting.

The following results were obtained:

Area of Supply in Square Meters	Height of First Sympodial Node July 7	October 18
3 675	5,1	5,1
3 412	5,2	5,1
2 475	5,2	5,6
1 688	5,0	5,9

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"In cases of close spacing, the fruiting branches put out seasonably at the lower nodes do not develop to maturity and their abscission occurs; sometimes, where they are not shed, they remain so undeveloped as to escape notice of the counter". This is one explanation of the delayed opening of the bolls which is observed in the Old Cotton Regions and sometimes in the New Regions as well. Another current explanation reduces to pointing out the greater amount of shade produced on the lower levels by the leaves, thus creating the conditions for lowered temperature, increased atmospheric humidity, etc. in the closely spaced plantings as compared with the sparsely spaced ones.

The reverse phenomenon - acceleration of boll opening time under the influence of close spacing Lt. F. Antropov) - is explained by the lower heat requirements of the small closely-spaced plants; or sometimes by the earlier uncovering of the drying soil when spacing is close. In any case there is still no completely satisfactory explanation of the sometimes directly contradictory results which have been observed.

It is of practical importance to bear in mind that, in contrast to the Old Cotton Regions, the most closely spaced plantings frequently start to flower earlier and frequently open the bolls earlier than the sparsely spaced plantings under the conditions of the New Cotton Areas. Under the influence of close spacing the height of the main stalk is sharply diminished, while the number of monopodial branches is so drastically reduced as even to be eliminated in some cases.

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Close spacing results in shortening the sympodial branches, which most frequently of all bear only a single boll.

With an average area of supply of 600-700 square centimeters, a single plant has usually no more than three or four bolls, and the size of the bolls is reduced.

Area of Supply for Each Plant	Weight of a Single Boll in Grams	
	Khasav-Yurt, 1930	Taman', 1931
60 X 5	-	3,6
60 X 10	3,4	3,8
60 X 20	3,8	3,9

According to observations in Transcaucasia and other areas, the percentage of 3-lock bolls is increased and that of 5-lock bolls is reduced under the influence of close spacing, which also considerably increases the area of the leaf surface /N. N. Balashov, "Density of Cotton Planting." Trudy Uzbekistanskoy S. Kh. Stantsii, VYP. 2, 1926./7

Almost all experiments with area of supply made in the New Regions have used "Shreder" No. 1306 variety, which has a rather compact form. The plant breeders of the New Regions are working to introduce varieties with even more compact forms, storm-proof and suitable for mechanized picking (of branch type from 0 to 1).

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It is interesting to note that "the percentage of yield increase specific for each variety and the degree of yield increase depends on the branching type of the sympodial branches; the bushier it is, the stronger will be the effect of close spacing; the more diffuse and open it is, the more feeble the reaction of the variety will be to any change in the area of supply" (I. S. Varuntsyan).

Density of Stand and Fruiting

The fruiting of the individual plants is reduced as spacing is closer. A considerable number of non-bearing plants, for instance, was noted at Prikumsk and Taman' during 1931.

Area of Supply Per Hill	Number of Plants To The Hill	Percent on Non-Bearing Plants Prikumsk	Taman'
30 X 30	1	0	2
	2	7	9
	3	13	24
50 X 50	1	0	2
	2	5	11
	3	11	6
70 X 70	1	0	1
	2	6	2
	3	8	4

The percentage of non-bearing plants increases most sharply with increasing number of plants per hill; the lower the hill's area of supply the more vividly the phenomenon is observed.

Nevertheless, in most cases close spacing gives a larger lint yield per unit area and in shorter time.

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The data on number of bolls, according to "cones of fruit formation" for closely spaced and widely spaced plantings on Taman' (1931) and Khiva (Uzbek SSR, 1928) are presented below.

Area of Supply	I	II	III	IV	V	Total Number Of Bolls
Taman', 1931						
60 X 10	2,3	1,9	0,7	0,1	--	5,0
60 X 20	2,4	3,4	2,3	0,5	--	8,6
60 X 30	2,5	3,9	3,2	1,2	0,3	11,2
60 X 40	2,6	4,2	3,8	1,4	0,1	12,1
Khiva, 1928						
50 X 7,5	1,5	1,4	0,4	--	--	3,3
50 X 15	2,1	2,6	0,8	0,1	--	5,6
50 X 30	2,2	3,6	3,0	1,5	0,1	10,4
50 X 45	2,6	4,1	4,7	2,9	0,7	15,0

The material presented explains the cause of the accelerated tempo of accumulation of the harvest per unit area in comparison with the widely spaced plantings. The full harvest of closely spaced plantings consists mainly of opened bolls of the first two cones which mature earliest, while the bolls from these same cones hardly give half of the total yield where spacing is wide.

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The considerable increase in the percentage of the first picking, which is almost always observed in closely spaced cotton, is thus rendered comprehensible.

For instance, on October 10, 1931, the following percentages of the total crop were harvested from plots with varying areas of supply.

Area of Supply	Percent of Total Crop Picked On October 10, 1931
60 X 5 70	60 X 30 51
60 X 10.....69	60 X 40 45
60 X 20.....66	

Even for Central Asia (Tashkent) the well-known scholar, Prof. R. R. Shreder propagandized long before the revolution in favor of close spacing as a method of protecting the cotton crop from the early Autumn frosts. For the New Regions the property of close spacing of increasing the percentage of the first picking is even more significant, for the first frosts often come early and the weather of late Autumn is often unfavorable for cotton picking.

The shortening of the picking season by close spacing makes it possible to bring close to solution the problems of reducing the number of pickings and of mechanizing cotton picking.

Quality of the Crop From Close Spaced Plantings

The shortened period of boll opening that results from

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close spacing allows finishing the picking before the onset of the unfavorable late autumn weather and thus to a considerable degree safeguarding the crop from the fungus and bacterial deseases that usually affect lint in the New Regions. There is no doubt that close spacing can help to raise the quality of the crop of the general production of cotton growing.

The Azerbaydzhan Station (I. S. Varuntsyan) studies the crops resulting from close spacing and reached the conclusion that "close spacing of plantings has absolutely no influence" on fiber length.

The absolute weight of the seed is considerably reduced under the influence of close spacing, but with very little reduction of the non-ash weight. As a result, increase in the percentage of fiber by weight is often observed.

The following data on crop quality have been obtained in the New Areas:

Area of Supply	Percentage of Fiber Yield	Fiber Length	Percentage of Fiber Yield	Fiber Length	Weight of 1000 Seeds
60 X 5	30,1	26,5	--	--	--
60 X 10	30,2	26,3	33,3	23,6	84
60 X 20	29,9	26,6	33,7	24,4	86
60 X 30	30,5	26,2	--	--	--
60 X 40	30,5	26,3	--	--	--

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This indicates that the changes in fiber yield and fiber length are insignificant.

Shape of the Area of Supply

An experiment at the Kherson Station in 1931 showed that with equal area of supply per plant, the shape of the area of supply is also significant. It might seem that given equal areas of supply it would be most advantageous to space the plants at equal intervals. In fact, however, the experiments indicate the advantage of the elongated area of a supply over the square shape.

"Shreder" No. 1306 variety was planted on May 7, 1931. Data was taken from 10 plants in each plot, and the following results were obtained:

Area of Supply	Interval in Days Between Planting and		Lint Yield In Tsentner Per Hectare	
	Flowering	Maturation	To Oct. 10	Total
60 X 5-300 KB. CM	75	125	14,5	25,4
17 X 17,6-300 KB. CM	78	135	12,2	23,7
90 X 5-450 " "	76	126	10,5	23,8
20 X 22,5-450 " "	77	132	10,7	20,9
60 X 10-600 " "	77	126	10,9	20,3
25 X 24-600 " "	77	130	9,8	19,4
60 X 20-1 200 " "	77	126	8,1	17,1
35 X 34,5-1 200 "	76	129	7,3	16,6

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These data convincingly indicate the advantages of the elongated area of supply, which, in comparison to the square shape increases lint yield and plant stature and accelerates the onset of boll opening. All these modifications are quantitatively greater on small areas of supply (300-450 square centimeters) than on small areas of supply (300-450 square centimeters) than on large ones (600-1200 square centimeters). The same station made an analogous experiment in 1932 and obtained the same results.

The explanation must be sought in differences between the heat and light regimens of the "solid" square planting as compared with row arrangements. Moreover, the root system, restricted on only two sides in a row arrangement, can more successfully develop long laterals than it can in a "solid square" arrangement, and with the rows widely spaced, the laterals can remain longer in the fertile humus horizon.

Soil Moisture and Density of Planting

The New Cotton Regions are located in a belt subject to drought. Closely spaced planting gives greater leaf surface, develops a greater overground mass and requires more water than widely spaced planting.

At Taman', a somewhat greater drying out of the soil was found in 1931 to result from close spacing.

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Close Spaced Layout	Percent of Moisture in The 50 Centimeter Soil Layer			Percent of Moisture in The One Meter Soil Layer		
	June 4	July 21	Aug. 17	June 4	July 21	Aug. 17
30 X 30 with 3 plants	21,7	17,8	11,1	20,7	19,1	11,9
60 X 60 " 2 "	22,0	20,8	12,2	20,5	21,2	14,5
70 X 70 " 1 "	22,3	22,5	14,2	21,3	22,0	15,8

In research at Prikumsk (1931, 1933) the cotton plant was found to form 1.5 to 2 grams of overground mass for each kilogram of water consumed. In productive transpiration coefficient, cotton comes close to wheat and barley in the arid southeastern part of the USSR (this coefficient for wheat in that region ranges from 1.5 to 2, according to N. A. Maksimov).

However, according to the mean planned figures, the yield of overground mass in the case of wheat exceeds that of the closest stand of cotton. Thus a cotton field requires less water than a wheat field, to say nothing of the fact that the biological qualities of the cotton plant allow a very large margin with respect to the "critical" factors.

The New Regions have already had convincing experience of the drought-resistance of cotton in 1929 and 1930. Almost no plant among the cereals or tilled crops is its equal in this respect.

The observations of M. G. Taranovskaya (Kherson, 1931, 1932) on variety No. 1306 of cotton have determined the taproot and

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laterals to be considerably thicker when the plants are widely spaced than with close spacing, but at depths of 40-50 centimeters the roots of widely spaced plants already become very much thinner and go down to a considerably shallower depth than is the case with roots of closely spaced plants. Close spacing is well adapted to the satisfaction of the increased moisture requirements by developing deeper root systems.

In total root weight per unit area the closely spaced plants are favorably distinguished.

The weight of roots in the two-meter layer, large and small roots alike, with a 80 X 5 area of supply is double that with a 60 X 40 area of supply.

Closely spaced plants develop a far deeper and more ramified root system in their search for moisture and nutrients, and thus assure maximum yield of overground mass.

M. G. Taranovskaya obtained the following results in experiments with variety No. 1306 at Kherson in 1931.

Area of Supply	Height of Main Stalk	Weight in Tsentner Per Hectare		Ratio Between These Weights
		Overground Mass	Roots	
60 X 40	58	23,4	6,4	3,7
60 X 20	45	43,0	9,3	4,6
60 X 5	41	74,6	11,8	6,8

The roots of closely spaced plants are able to develop an overground mass of seven times their own weight, while with wide spacing this ratio is only four times.

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Researches on the root system give still another argument in favor of close spacing of cotton plants.

The Ak-Kavak Station obtained the highest yield, in all of the small and "massive" irrigation layouts under study with maximum density of stand (hills spaced 10 centimeters apart in the rows, and two plants to a hill). However, maximum effectiveness appeared with maximum watering" /A. F. Makarov, Stand Density of Cotton and the Water Regimen of the Soil.

It may be surmised that the maximum effects of close spacing will take place in the New Regions [redacted] in wet years. At the same time it is hard to believe, in view of even the present experience in arid years (Taman', 1929; Prikumsk and Khasav-Yurt, 1930 etc.) that there can ever be years when planting as close as 120,000, 150,000 plants per hectare would give lower yields than, or even yields as low as, those given by wide spacing (60,000 to 80,000 plants per hectare).

Solid Planting of Cotton

Successful experiments in growing soybeans have been made by eliminating tillage. The growing season of the soybean permits of late solid planting of soybeans less than that of cotton. In the case of soybeans, the end of April and the beginning of May were used to provoke the intensified growth of weeds so as to destroy for a long time the good pre-planting cultivation.

In 1931, an experiment in solid cotton planting was made at Kherson. Planting was done on May 7 after a predecessor black fallow and after cotton.

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	Yield In Tsentner Per Hectare	
	After Fallow	After Cotton
Solid S Planting, 20 X 15	6,8	5,6
Control, 60 X 20	4,4	6,5

At first glance, the results of the experiment speak for the feasibility of solid planting. The control plots were cultivated morally, while the plots for solid planting only received a single hand weeding during the time of the first cultivation, in consequence of which the cotton was overrun by weeds. But these results cannot be recognized as satisfactory for the reason that even a single continuous hand weeding is inadmissible during vegetation and besides that it would be impossible to interrupt the active struggle with the weeds and encourage their further spread and proliferation even if they had no influence at all on the yield. These data were obtained on slightly weedy soils of a long-established research institution. It would be the grossest error to apply these results to practical operating conditions.

Practical Indications

One of the most important practical tasks of the struggle for high cotton yields in the New Regions is the control of seeding mortality.

One of the reasons for the inadmissably low yields is the systematic non-fulfillment by many sovkhozes and kolkhozes of the established agronomic rules for standard density of stand.

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Most fields have only 40,000 - 70,000 plants to the hectare instead of 120,000 to 140,000.

According to data of the Crop Forecast Service, under the conditions of the impermissably low level of cultural practice in past years, the relation of dependence between the actual productivity of kolkhozes fields and the density of stand is expressed by the following columns (according to figures of the control sections of the sovkhozes and kolkhozes.)

Number of Plants in Thousands Per Hectare	Yield in Tsentner Per Hectare
15 -- 40	0.5
40 -- 60	0,5 -- 1,5
60 -- 80	1,5 -- 3,0
80 --100	3,0 -- 5,0
over - 100	over 5,0

Stand density had this effect on yield under operating conditions. The struggle to attain an even, dense stand and the struggle against seeding mortality require no special measures.

All that is necessary is careful and timely preparation of the soil, correct and timely planting at the full, prescribed rate of seeding, and careful measures of weed control during the growing season. In the fight against seedling mortality, special attention must be paid to strict control of the accuracy of thinning at precisely the established intervals. The agronomic rules for all the New Cotton Regions have prescribed the

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following areas of supply:

a. For hand cultivation in the rows. Space between rows 70 centimeters. Distance between plants in the rows 10 centimeters for one plant per hole and 20 centimeters for two plants.

b. For excellent mechanized cultivation. Space between rows 70 centimeters. Length clumps 25-28 centimeters Distance between clumps 45-42 centimeters. Five plants to be left in each clump after thinning.

MANAGEMENT AFTER COTTON PLANTING

Incrustation Control

The capability of a soil for forming incrustations after rain depends mainly on the ability of its structural aggregates to resist the disintegrating action of rain, i. e. on the structural stability of the soil. The chestnut chernozems and chestnut soils of the New Cotton Regions are less subject to incrustation than the heavy light-colored soils of most cotton Regions in Central Asia. This is explained by the fact that the soils of the New Regions are relatively richer in organic substances. The humus substances which are formed in the soil during the process of decomposition of organic remains are the principal substances that cement the soil particles together and impart a stable structure to the soil.

Incrustations do not usually form on freshly broken virgin land or on fields after perennial grasses have been grown.

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In consequence of their low content of clay particles, light sandy soils do not usually form firm and cohesive incrustations after rain. Cotton growers are very familiar with the damage done by heavy rains immediately after planting, for these form continuous incrustations on heavy soils, which retard the emergence of the cotton seedlings and result in seeding mortality and sometimes even in the loss of the entire planting.

There are seasons in the New Cotton Regions as well when seeding mortality may be high as a result of incrustation.

Incrustation is particularly serious in cold rainy springs, when the warmth-loving cotton seedlings and shoots cannot develop sufficient energy to overcome the mechanical resistance of the soil.

In the Cotton Areas of Central Asia incrustations are not infrequently washed away by a special irrigation, followed by cultivation with a dandana (serrated wooden board), Ketmen' or Urak (a kind of sickle).

At Khorezm, on particularly heavy soils, the application of manure with sand, or even of unmixed sand, is practiced to prevent incrustation and increase soil fertility.

Harrowing with a zigzag harrow at right angles to the planted rows is recommended at the present time for incrustation control in Central Asia.

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Such harrowing is only recommended before emergence of the seedlings, and only while the incrustations are still drying and the whole field is still slightly damp and only the large clods have dried off to lighter color. [G. M. Meyerson, "A Contribution To The Question of Soil Incrustation and Its Control". "Za Khlopkovuyu Nezavisimost'", No. 4, 1931. Tashkent.]

It is better to work with the zigzag harrow in the morning, when the crust is softened by the increased atmospheric humidity. In Central Asia, the French harrow is used where the incrustation has dried out; this harrow packs the soil badly and damages many seedlings.

Until the emergence of the seedlings, it is necessary to control incrustation in the New Cotton Regions by using the zigzag harrow at right angles to the line of planting at the moment the incrustation "ripens". Time is of the essence in this work, since inside of a day - and in hot weather even inside of half a day - the crust may become desiccated, in which case harrowing will result in damage to a considerable number of the emerging seedlings. Among the seedlings, as a measure of incrustation control, is permissible only under the supervision of an agronomist and only where the crust has not already dried out and set. Incautious harrowing of the seedlings often does more harm than good.

In 1931 the Tamsk Station experimented with twice-repeated harrowing of seedlings. The first was done on May 21, on the fifth

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day after emergence and after abundant rainfall, with the second one on June 3, also after rain. Seedling mortality of 8.7 percent, as against an unharrowed field, resulted from the first harrowing, while the second one caused an additional 0.5 percent loss. In consequence, yield was reduced by 1.4 tsentner per hectare, or about 12 percent.

Where seedlings are dense and uniform, harrowing with the zigzag harrow in the event of incrustation is not dangerous to them. On the contrary, harrowing reduces soil evaporation, removes some of the emerging weeds, and cuts the outlay of labor for thinning the excess plants.

In working with the zigzag harrow the chains (traces) must be lengthened, so as to give the harrow a "percussive" action, i. e. it must rebound and not scratch the earth. When incrustation occurs after seedling emergence and it is impossible for a number of reasons to do harrowing, the spaces between rows must be immediately tilled with cultivators and the crust in the rows destroyed by hoeing.

Among the measures to avoid incrustation damage on soils prone to incrustation, it is necessary to point out increase in the seeding rate, shallow depth of seeding (3-4 centimeters) and proper working with the seed drills. On such soils planting should be done during the end of April or the beginning of May, since cotton seedlings are better able to penetrate incrustations in warm weather.

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The most perfected implement for incrustation control is the rotary scraper, which does only insignificant damage to the seedlings, since the spiders wheels of the scraper only break the surface layer of the soil and hardly displace the soil particles.

Two parallel shafts revolve on bearings mounted on each of the three angle brackets of the rotary scraper.

Spiders consisting of a cast-iron core with projecting steel fingers are mounted on each shaft.

Each shaft has up to 15 spiders, if the operating width is 2 meters. In motion the spiders rotate freely about the shaft and prod the incrustation, forcing it to crack.

In comparative tests of incrustation control implements at Tashkent, it was found that with large seedlings (5-7 centimeters), 17 percent of the plants were damaged by the rotary scraper, 37 percent by the zigzag harrow and 40 percent by the French harrow.

When seed drills are used having rollers for rolling down the planting furrows in the earth, thus forming incrustations, changing the form of the roller by increasing the camber in the center may be recommended.

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Tests of different forms of rollers with the banner seed drills showed that increasing the camber permitted obtaining 28 percent more seedlings from plantings that had become covered over by incrustations (Ak-Kavak Station). "The formation of incrustations of varying thickness is explained by the fact that when rain falls on the hillocks and runs off, the hillocks are less soaked than their bases. When the hillocks dry through, fissures appear on top, which favors the simultaneous emergence of the seedlings. When rollers with small camber are used, the rain water remains on the entire surface of the planted area, and therefore the incrustation is continuous and coarser" /P. Yazykov, How and With What To Fight Soil Incrustation. Tashkent, 1932./

During 1930-1933, the cotton growing industry was most frequently damaged by incrustation in the Cotton Areas of the Ukraine, with less damage done in the North Caucasus.

The Significance of Management After Planting

The principal condition for high yields is the timely and correct cultivation of the cotton fields during the growing season, which is mainly directed towards weed control. The low average yields during recent years in the New Cotton Regions are due primarily to the systematic non-fulfillment of the regularly prescribed weeding operations.

On the average during the three years (1931-1933) only 51 percent of enterprises had completed the first weeding by the deadline set by the Government (June 10), while the second weed-

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ing was done in prescribed time in only 18 percent of the cases, and the third weeding was not done at all.

The percentage of fulfillment of the regular weeding operations by years, is shown by the subjoined table.

The cotton crop in the New Cotton Regions was weeded even more badly in 1933 than in 1931.

The government plan for cotton production was already overfulfilled in 1933 by Central Asia and Azerbaydzhan, thanks to their timely and careful management of the cotton fields. "Kazakstan is rather a bad point in this respect, to say nothing of the unirrigated cotton areas, where the cotton crop slipped completely this year, but cotton is the crop that reconciles itself least of all to slackness and slovenliness in its planting and cultivation" (from the report of Comrade Yakovlev to the IV session of the TsIK USSR on January 2, 1934).

	Three-Year Average	1931	1932	1933
First Cultivation on June 10	51	64	42	47
Second " " June 25	18	31	10	14
Third " " July 15	1	0	0	3

Every single cotton sovkhoz and kolkhoz can obtain the same high yields as the Zonal Stations do. The following yield data in tsentner per hectare were obtained in 1931 by two large-scale cotton farms in the Ukraine and North Caucasus. They testify to the truth of the above assertion. They are for dif-

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ferently cultivated fields, and are compared in the following table with average yield for corresponding Rayon and Republic (or Kray).

	Yield On The Demonstration Field	Yield On The Best Cultivated Parts Of The Farm	Yield For The Farm As a Whole	Yield For The Rayon	Yield For The Republic (or Kray)
Pyatirichka Artel, Skadovskiy Rayon, Ukrainian SSR	18	12	8	4,0	2,7
Area Under Cotton: 876 Hectares	667%	444%	296%	148%	100%
Sovkhoz Bugasskiy, North Caucasus	19	12	6	2,8	1,7
Area Under Cotton: 2278 Hectares	1,118%	706%	353%	165%	100%

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In years of unfavorable meteorological conditions, tardiness in fulfillment of the weeding operations results in even greater yield reduction than in favorable years.

In 1933, which was unfavorable in meteorological conditions, the kolkhoz imeni 9 January in Prikumskiy Rayon obtained a yield of 7 tsentner per hectare from its total planted area of 304 hectares, while at the same time most kolkhoz in the Rayon obtained yields of 1-2 tsentner.

Hundreds of examples of high yields could be cited, and all of them explained, not by excellence of soil or climatic conditions for the farm in question, but exclusively by cultural practice and mainly by their timely fulfillment of the weeding operations.

The work in management of cotton crops reduces down to the following agronomic tasks: 1. destruction of weeds; 2. improvement of the air and water regimens of the soil by means of periodic cultivation of the surface layer of the soil; 3. rational arrangement of plants on the assigned space by means of removing the surplus plants by thinning.

The fulfillment of these tasks is attained by periodic tillage between the rows, using cultivators; by undercutting the weeds with tongs; and by clearing a narrow belt around each plant by hand with mattocks and sickles.

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In recent years the method of mechanized cross cultivation has commenced to gain citizenship rights. This involves the use of cultivators, followed by hand cultivation of the remaining "clumps", which have a total area of only 14 percent of field area.

When plowing is only done between the rows, 40 percent of total area is in the rows and is cultivated by hand. Thus 86 percent of total field area is cultivated by machine in the case of cross cultivation, as against only 60 percent for ordinary lengthwise cultivation.

Cross cultivation is practiced mainly in the KhLOPKOSOVKhoZY. Even in 1933, mechanized lengthwise cultivation is very frequently not practiced in the kolkhozy, and field cultivation over the entire area is done entirely by hand hoeing in such cases.

Time For Thinning Cotton

In the Cotton Regions of Central Asia, thinning of seedlings to the prescribed distances between plants is usually timed by one of two methods: either by the appearance of 1 to 2 full leaves, or else by that of 5 full leaves.

If only a single thinning is done, it is usually done when two pairs of leaves have appeared.

Experiments on thinning times in the United States have been mainly conducted on late varieties inclined to strong monopodial branching.

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The Americans have attempted, sometimes not without success, to suppress this tendency to monopodial branching by practicing late thinning. In the state of Texas, where conditions most nearly resemble those in our New Regions, thinning is done at 4-6 leaves.

Experiments to determine the optimum time for thinning were carried out in the New Cotton Regions in 1931 and 1932, and also had the aim of determining whether it was really necessary to continue the practice of making two thinnings, which had been carried over from Central Asia into the practice of the New Regions and is based on the danger of a large number of plants dying, after the early and final thinning, from unfavorable weather conditions, past damage, root rot, etc.

Single thinning at different stages was compared in the experiments to double thinning done at the appearance of two or six full leaves.

"Shreder" No. 1306 was the cotton variety used.

Tabulation of the percentage of mortality, expressed in percent of the assigned area of supply, gave the following results.

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Thinning At Time Of Appearance Of	Kherson 1931	Taman' 1931	Taman' 1932	Prikumsk 1931
Cotyledon	15	40	12	13
2 Full Leaves	8	32	20	9
4 " "	10	37	8	5
6 " "	6	30	7	0
2-6 " "	6	31	6	6

Increased mortality is more or less distinctly expressed with the earliest thinnings.

Yield tabulation showed almost the same results for all thinning methods variants involved in the experiment. Yield data is on the basis of tsentner of lint per hectare.

Thinning At Time Of Appearance Of	Kherson 1931	Taman' 1931	Taman' 1932	Prikumsk 1931
Cotyledon	18,1	14,7	19,4	7,9
2 Full Leaves	17,3	15,2	18,7	7,6
4 " "	15,7	16,1	18,0	8,6
6 " "	17,9	17,1	18,8	7,8
2-6 " "	16,8	15,4	19,2	8,4

In spite of some increase in mortality with earlier single thinnings, there was no reduction whatever in yield. The favorable action of early single thinning is mainly due to the elimination of the long period of mutually inhibitory influence exerted by closely spaced young seedlings, some of which play the role of weeds

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and take away water, nutrients, and to some extent light, from their neighbors.

"Yield reduction with delayed thinning occurs because the growing season is protracted, which enfeebles the growth and fruiting of the plants and to some extent also reduces the lint weight in the bolls." /N. N. Balashov, "Thinning Times For Cotton." Journal "Za Rekonstruktsiyu Sel'Sokogo Khozyaystva", No. 4, 1930. Samarkand./7 N. N. Balashov reached this conclusion after a two year study of thinning times at the Uzbekistan Agricultural Experiment Station (Tashkent).

In his experiments as well, early thinnings proved most productive, in spite of some increase of mortality.

The results of these experiments, conducted with variety No. 169 in 1928, planted on May 6, 1928, are presented below.

Thinning At Time Of Appearance Of	Percent Of Mortality	Yield In Tsentner per Hectare	Interval In Days Between Planting And Maturation	Number Of Bolls Per Plant
Cotyledon	19	18,2	147	7,7
1 Leaf	18	18,5	148	7,4
2 Leaves	17	17,7	148	7,1
3 "	16	17,0	148	6,8
4 "	15	15,8	150	6,5
6 "	13	14,2	155	6,5
10 "	14	14,4	153	5,8

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Delayed thinning also delayed maturation, reduced fruiting and yield, and somewhat reduced mortality. Mortality must be reckoned with in all cases involving widely spaced, enfeebled, non-simultaneous seedlings, whether because of incrustation, marked development of root rot, or simply unfavorable early spring weather. In such cases a certain delay in thinning must be recommended, or, better still, thinning once at two leaves and again at six leaves.

As a general rule in the New Cotton Regions, a single thinning is expedient at the appearance of 2 to 3 full leaves. The solution in principle of the question of the practicability of a single thinning has opened up a wide path for the mechanization of this kind of work.

With mechanized cross cultivation it is possible and desirable, for considerations of weed control, to have a very early transverse thinning at the appearance of the first leaf or even immediately after seedling emergence. In these cases the final thinning is done later, when 3 to 4 leaves have appeared, at the time of weeding the "clumps". In transverse thinning, special attention must be paid to the quality of the work; in particular, it needs to be carried out by hand and to leave only the healthy and most strongly developed plants. The prescribed spacing between the remaining plants must be strictly observed.

In connection with the tendency, in places, to space cotton plantings with extreme closeness, [THE Agronomic Rules For Ukraine in 1931 and 1932 Recommend Reducing the Space Between Plants in the Rows to 5 Centimeters.] proposals have been made to do away with thinning entirely.

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The question of the feasibility of excluding thinning from the list of obligatory operations was studied in 1932 in special experiments conducted at the Experiment Points of the Ukrainian Zonal Station.

[For Table see next page]

Under the conditions of these experiments, elimination of thinning reduced the yield of cotton. It may be argued that if the bases in question had reduced the seeding rate, there would have been no reduction of yield for the year. But on the other hand, the need for using increased seeding rates as a form of insurance against unfavorable spring weather has been discussed in detail earlier in this paper.

Even isolated successful experiments pointing to the practicability of dispensing with thinning can carry no force of confiction for all cases of field practice.

Here is an example taken from the experiments at Prikumsk in 1933, on large plots of 1.5 hectares, cultivated by mechanized cross cultivation.

	Number of Plants Per Hectare at Picking Time	Number of Plants in Each Clump	Pre-Frost Yield	Total Yield Per Hectare	Number of Bolls per Plant
Setting Up Clumps And Removing Surplus Plants Over Five	627700	4	0,7	5,8	4,3
Setting Up Clumps and Removing only Weeds without Thinning Of Cotton Plants	111,800	6	1,4	5,3	2,7

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Time Of Thinning	Skadovsk		Planting On June 6	Bashtanka		Planting On May 8
	Pre-Frost Yield	Total Yield	Interval In Days Between Planting and Boll-Opening	Pre-Frost Yield	Total Yield	Interval In Days Between Planting and Boll-Opening
At 2 Full Leaves	3,1	8,5	138	7,2	9,5	162
At 6 Full Leaves	2,4	6,2	142	6,2	8,0	162
At 2 and 6 Full leaves	2,7	7,0	142	6,4	8,4	162
Without Thinning	2,9	6,0	--	5,8	6,6	163

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These data indicate increase in the pre-frost yield and slight reduction of total yield where thinning was not done in the clumps.

In all cases where good seedlings emerge under usual seeding rates, there is a large number of excess plants, distributed irregularly over the site, which do not themselves bear fruit and undoubtedly reduce the yield of their neighbors. To dispense with thinning would be a step in the direction of a harmful simplification of agronomic practice, capable in some cases of sharply reducing the yield. To dispense with thinning is possible and expedient only in special seed growing cases under the condition of reduction in the seeding rate to 20-30 kilograms per hectare.

In such cases the possible reduction of the total yield would be compensated by realization of the maim objective, that of increasing the coefficient of reproduction of the seed, and particularly if increase in the pre-frost lint yield is also borne in mind, as was observed in the Pirkumsk experiment.

In 1933 the Taman' Station obtained the following results in an experiment with reduced seeding rates without thinning, for variety No. 1306, planted on May 1.

/See Table on next page_7

In 1933, the fiber yield on the Taman' was about 30 percent. The coefficients of reproduction of the seed, calculated from the pre-frost harvest, argue convincingly for the entire

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	Thousands of Seedlings per hectare	Thousands of Plants at the End of the Growing Season	Date When 50 percent of Bolls Had Opened	Total Yield in Tsentner Per Hectare	Pre-Frost Yield	Coefficient of Reproduction of Seed
20 Kilograms, without thinning	70	56	4/XI	6.5	2.1	7.3
35 " " "	91	68	5/XI	6.3	1.7	3.2
50 " " "	142	109	6/XI	6.5	2.0	2.8
65 " with thinning	187	65	2/XI	7.5	2.2	2.4

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expediency of planting at reduced planting rates without subsequent thinning, in special seed growing establishments, in spite of the reduction of total yield of lint and total fiber yield observed in such cases.

Planting of 20 kilograms of seed per hectare without tinning gave a coefficient of reproduction of 7.3, while with a sowing rate of 65 kilograms and subsequent thinning, the coefficient of reproduction was 2.4.

THE NUMBER OF CULTIVATIONS DURING THE GROWING SEASON OF COTTON

It has been indicated above that the cultivation of and weeding of cotton between the rows has two main objects: to destroy the weeds and to keep the surface layer of soil in a pulverized condition. Let us define roughly the significance of each of these objects.

In 1931 at Kherson an experiment was conducted during which some of the plots were systematically weeded and cultivated, while the rest of them were merely weeded, without cultivating the soil. The lint yield from the first plot was 17.5 tsentner per hectare, and from the second plot 16.6 tsentner.

The results of this experiment indicate that among all the operations involved in the management of the cotton plant during the growing season, the leading role belongs to weed control.

The number and time of the cultivations between the rows as well as of the cultivations in the rows mainly depends on the degree of weed infestation of the field, the presence or absence of malignant weeds, and to some extent, on the meteorological conditions of the

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season. Thus, in the arid years 1929 and 1930, the development of weed vegetation was suppressed by the drought, and in these years the cotton fields were kept clear with a minimum number of cultivations at the beginning of the growing season. In 1931, when warmth and rainfall were abundant, and especially in 1933, when warmth and rainfall were not quite so abundant, it was possible to cope with the weeds only by frequent and timely cultivations. To note the minimum number of cutlivations required, the best way is to consider the results of experiments with inter-row cultivations in damp years.

In 1931 at Prikumsk, there was an experiment to ascertain the feasibility of omitting hand cultivations in the rows if the spaces between the rows received frequent cultivations, and hand cultivation was done only once at the time of thinning.

Tabulation of the lint yield picked before the early frosts gave the following results:

	Pre-frost yield in tsentner per hectare
1. Without any cultivation whatever	0.8
2. Three cultivations without hand tillage	4.0
3. Same, plus timely hand tillage	6.3
4. Cultivations* without hand tillage	4.3

*/Translator's note: Number of cultivations presumably omitted by printer's error/

Even on the relatively less weedy fields of the experiment institute, a sharp reduction in yield was noted when hand cultivation in the rows was omitted.

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Under the conditions of the more weedy fields of some sovkhozes and kolkhozes any employement of cultivation without concurrent hand weeding in the rows must be regarded as doing more harm than good. To cultivate only the spaces between the rows creates good conditions for the growth not only of the cotton but also of the weeds in the rows. The cotton plants must inevitably be stifled at an early stage of development unless there is active control of the weeds in the rows.

In 1931, at Taman', an experiment was performed in the middle of weed overgrown fields. During the initial period of vegetation of the cotton plant, rape, thistles, shepherd's purse, sweetclover, saltwort and other weeds developed on the plot. In midsummer, phleum boehmeri grass, amaranth, European bindweed, orache and khondrilla appeared.

After the flowering of cotton, orache, amaranth, saltwort, khondrilla and thistles still remained on the plots. In an analogous experiment at Kherson in the same year, phleum boehmeri grass, amaranth and European bindweed prevailed.

[For table see next page]

At Taman' there were a number of plots on the same tract where the weeds were permitted to grow freely. On July 6 the weeds yielded a "harvest" of dry overground mass weighing 2043 grams to a plot (160 square meters) while at the same time, after two weedings and two cultivations on different plots, the weeds were only able to develop 88 grams of aboveground mass per plot.

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Number of Cultivations	Number of Hand Weedings in the rows	Yield in Tsentner per Hectare	Dates of Cultivations	Dates of Weedings
Kherson, 1931				
2	2	16.8	June 2 and 27	June 11 and July 7
0	4	13.5	none	June 11 and 29, July 7 and 23
0	1	5.6	none	June 11
3	3	16.0	June 6 and 24, July 7	June 11 and 27, July 7
Taman', 1931				
2	2	17.6	May 24 and July 6	June 6 and 22
3	2	19.1	May 24, July 6 and 22	June 6 and 22
3	3	17.8	May 24, July 6 and 22	June 6 and 22, July 22.

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Figure 27 (page 153) Cotton Field that Received three Cultivations. Note spots overgrown with Scutch Grass. (Field near Kerch').

The results of the experiment show that 2 - 3 cultivations and 2 hand weedings in the rows assured the highest yield.

There was a certain yield reduction when the number of hand weedings was increased to 3 or 4. This is explained by mortality due to damage during the weeding.

The reservation must again be made that these results were obtained from experiments on fields relatively little overrun by weeds and with malignant weeds almost totaly absent, in a year while, while favorable to the growth of weeds, was also favorable to the rapid growth of the cotton plant. Under the conditions prevalent in most of the sovkhozes and kolkhozes of the new regions, theminimum number of cultivations required to assure proper weed control and maximum productivity is 3 hand weedings in the rows and 4 cultivations.

This statement is based on the experience of a large number of farms.

Figure 28 (page 154) Part of the same Field shown in Figure 27 after six cultivations, which cleared away all the Scutch Grass and assured better development of the cotton.

Where cotton fields are very badly infested with malignant weeds such as scutch grass, hand weeding should be intensified throughout the entire field and not merely limited to the rows, since the operating parts of the presently existing cultivators can cope only very inadequately with marked infestation of scutch grass.

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Special attention must be paid to hand weeding of the separate patches (kulig) of scutch grass, so as to prevent their further spread. Six to seven weeding operations during a summer is the rough minimum necessary to guarantee good index numbers.

In experiments with cotton at Kerch in 1931, the Nikitskiy Botanical Garden succeeded in fully protecting cotton from strong scutch grass infestation by merely doing frequent mattock work every 20 days throughout the entire growing season.

TIMES FOR WEEDING

The greatest damage from weeds is observed at the inception of vegetation, since the growth of the cotton plant is very slow during its initial period of growth and it is very easily stifled by weeds. Most weeds, on the contrary, grow with extraordinary rapidity in spring and early summer. This explains the necessity of doing most of the cultivating work on cotton during the first stage of its vegetation.

The fields usually start to grow green with weeds at the same time that the cotton seedlings emerge, sometimes even earlier.

It is usually necessary to do the first cultivation and the first hand weeding immediately after the seedlings emerge, as soon as the rows become discernable. The seedlings emerge in the middle of May, usually, or during the last ten days of that month.

The second cultivation must be performed as soon as two leaflets have appeared. At the same time, a second hand weeding and thinning to the prescribed spacing must also be done. This work must all be finished not later than June 15 - 20. A third cultivation and a third weeding in the rows is done when the first buds appear (5 - 6 full leaves). The third tillage must also be completed by the end of June or the

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beginning of July.

This order of operations completely guarantees fields clear of weeds and consequently also maximum yield.

The fourth cultivation is performed before the beginning of flowering. In the absence of weeds, itmust be done with cultivating tongs. A fourth hand weeding is necessary only in cases of strong weed infestation.

In 1933 an extremely interesting experiment was made at the Taman' Zonal Station with the object of determining the influence of delay in the separate cultural operations.

Cotton development was late in that year on the Taman', and the regular cultivations were done at the following times:

First cultivation and weeding	June 5
Second cultivation and weeding	June 25
Third cultivation and weeding	July 23.

The check plots were tilled at these times to give the first variant of the experiment. In the second variant, all these operations were performed ten days later. In the third variant, the first cultivation was done at the time for the second cultivation, i.e. was in fact omitted.

In the fourth variant, the first cultivation was perfomed on time, but the second was done at the time for the third. Finally, in the fifth variant, the third cultivation was omitted, but the first and second were done on time.

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The experiment tract was considerably overgrown by weeds and in no way distinguished from the fields of the neighboring kolkhozes. Planting was done on May 12 with a two-row Armalit planter. The plots were each 250 square meters, and there were four of each variant.

The results of the experiment are shown in the following table:

Times and number of cultivations	Date of 50 percent flowering	Percent of Plants matured on November 11	Height of Main Stalk
Check plot: 3 timely cultivations	August 10	50	48
All operations 10 days late	August 12	49	45
First Cultivation omitted	August 26	12	30
Second Cultivation omitted	August 29	21	22
Third Cultivation omitted	August 11	50	40

The yield reduction from delay or omission of cultivations is shown by the following tabulation of yield data:

Times and number of Cultivations	Lint yield in tsentner per hectare	Pre-frost crop in percent of total crop	Yield in percent of check plot yield	Number of bolls per plant
(1)	(2)	(3)	(4)	(5)
Check Plot: 3 timely cultivations	7.87	29	100	5.4
All operations 10 days late	6.35	41	81	5.4
First cultivation omitted	2.30	9	29	3.5
Second cultivation omitted	1.10	47	14	1.2
Third cultivation omitted	4.95	48	63	3.5

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Three cultivations done on time yielded about 8 tsentner per hectare.

A ten-day delay in all operations reduced total yield by almost 20 percent.

Postponement of the first weeding to the time for the beginning of the second weeding, i. e. ommission of the first weeding, reduced the yield by 70 percent, reduced fruiting and very strongly (9 percent) [Possible printer's error; Translator's note] reduced the pre-frost yield. The onset of flowering was delayed 16 days in this case. The mean height of the plants was not over 30 centimeters, or 18 centimeters lower than that of the well cultivated plants in the check plots. Omission of the second cultivation was even more significant. Yield was reduced by 86 percent in this case and approached the mean yields of many kolkhozes on the Taman' Peninsula in 1933. Flowering commenced 19 days late, and the cotton plants, stifled by weeds, had only an average of 1.2 bolls to the plant, with a stunted height of 22 centimeters.

In this case even the punctuality of the third cultivation could not save the crop. Moreover, the untimeliness of the second cultivation completely destroyed the value of the operations of the first cultivation and weeding, which were made at the normal time.

It should be remembered that only 18 percent of the area under cotton in the new cotton regions, on the average for the three years 1931 - 1933, received timely cultivation before June 25. It is not surprising that with such cultivation the actual yield obtained by most kilkhozes was 1 to 2 tsenter.

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The third cultivation was less important in comparison with the first two.

However, omission of the third cultivation and weeding in the rows reduced the total yield by almost 40 percent.

In 1931 the following experiment was made under the same conditions of fields overgrown with weeds at the Taman Station:

1. Two cultivations, on May 24 and June 6 and two weedings, on June 6 and 22, gave a crop of 17.6 tsenter from 1.6 hectare.

2. One cultivation and one weeding on July 6 and 10 respectively. In this case the first two tillages were in fact omitted, and by analogy with 1933, expectation of complete crop failure would have been justified However, in 1931 the lint yield from such plots was 11.7 tsentner per hectare. The 1931 season was warm and moist, and exceedingly favorable for cotton, in contrast to 1933, which was cold and moist.

The latter fact emphasizes the accuracy of the opinion expressed by V. E. Reyngard in "Cultural Practice, Weather and Leadership"; (Socialist Agriculture, 1931) to the effect that non-fulfilment or delayed fulfilment of the Agronomic Rules bears hardest of all on cotton production in unfavorable seasons.

MECHANIZED CROSS CULTIVATION

Mechanized cross cultivation was successfully employed for the first time in the new regions by the agronomist S. T. Kosenko in 1931, on the Bugasek Khlopkosovkhoz and on the Krasniy tamanets Kolkhoz in North Caucasus.

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In 1932 NOVNIKhI carried out an experiment with cross cultivation at the Stodervskiy Khlopkosovkhoz in North Caucasus. In 1932 and 1934 cross cultivation is already mentioned in the Agronomic Rules. In distinction to mechanized thinning the term cross cultivation is used in the sense of a tillage method which permits repeated operations of cross or transverse cultivation.

Many variants have been proposed with varying width of thinning and varying length of the remaining clumps. At the present time NOVNIKhI recommends the variant allowing a thinning width of 42 to 45 centimeters and a legth of 28 to 25 centimeters for the remaining clumps

STZ, KhTZ, John Deere and Farmall tractors with narrow chassis can freely do transverse cultivation with these distances.

With the first three of these tractors there is a margin of 2.5 centimeters left between the edge of the clump and the wheel-rim, but even if we assume that a part of the 28 centimeter clump (at most 8 centimeters) will be crushed by the tractor wheels, this would only involve 3 - 4 percent of the number of the plants crushed by working with tandem coupled "Aksay" No 8 cultivators.

A considerable number of the plants which are ridden down recover again. When the "VIM" cultivator No. 1 is used, which has a working width of 7 meters, the percentage of affected plants is still further reduced. 20,400 clumps or over 100,000 plants to the hectare may be obtained with closely spaced and simultaneously emerging seedlings and proper cultivator work.

The first transverse cultivation when using the recommended

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method is done with the same distance setting of the operating parts as is used in longitudinal cultivation. The application of mechanized cross cultivation is permissible only with good seedlings, free from mortality, and only where there is no strong rhizocarpic weed infestation.

This method gives good results only when all tillage operations are precisely and punctually performed.

The first lengthwise cultivation between the rows is done when the seedlings begin to emerge, as soon as the rows can be discerned. The first transverse cultivation (clumping) is done when one to two full leaves have appeared, and is done with the aid of markers periodically laid down on the field.

The cultivators are adjusted to the shallowest depth (3 - 4 centimeters) so as to reduce to a minimum the damage caused by covering the seedlings with earth.

Following the transverse cultivation, but not later than the appearance of two to three full leaves, hand weeding and thinning of the excess plants (over five) is done in the clumps. The healthiest plants are left, insofar as possible at the center of the clump, to reduce the danger of damage by the tractor wheels when transverse cultivation is repeated. The second lengthwise cultivation is done at the same time. When 4 - 5 full leaves have appeared, there is a second transverse cultivation, and a second hand weeding in the clumps. To avoid damage to the outer plants in the clumps, the reach of the operating parts of the cultivator is set this time at only 30 centimeters instead of 40.

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At the onset of budding, a third lengthwise cultivation is performed and followed by the third hand weeding of the clumps.

A fourth lengthwise cultivation is done before flowering.

Delay in commencing cultivation is impermissible. Any retardation will result in allowing the weed vegetation to consolidate its position, with the result that the working parts of the cultivators quickly become clogged with weeds and cut the remaining weeds inefficiently.

In 1932 the Taman' Station tested mechanized cross cultivation of cotton fields in comparison with the usual method of management (lengthwise cultivation and hand weeding in the rows).

The yield was 9.3 tsentner in the former case, and 13.2 tsentner in the latter.

1933 experiments at Prikumsk proved the possibility of obtaining the same yields with mechanized cross cultivation as with the usual method of cotton management.

/For table see next page/

The work was done by "Aksay" No 8 and "VIM" cultivators, drawn by STZ Tractors.

The tract was considerably overgrown with weeds, though there were not many rhizocarpic weeds (scutch grass).

With timely and correct mechanized cultivation even the variant "untrodden by human foot" yielded 3.7 tsentner of lint per hectare.

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Methods of Management	Number of Clumps per Hectare at Picking time	Number of Plants per Hectare at Picking time.	Pre-frost Lint Yield per Hectare	Total Yield per Hectare	Average Number of Bolls per Plant
Two transverse and three lengthwise cultivations, thinning and two hand weedings of the clumps	16,945	62,696	0.7	5.8	4.3
The same, omitting thinning and hand weeding in the clumps	19,176	124,644	0.7	3.7	1.5
Three lengthwise cultivations and two hand weedings in the rows, with thinning space of 10 centimeters between plants in the rows	---	86,224	1.1	5.8	4.0

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With hand weeding of the clumps, mechanized cross cultivation gave the same yield as the ordinary method.

This experiment indicates the wide possibility of mechanizing weeding operations to a very considerable extent on the cotton fields of the new regions, in the first place in the khlopkosovkhozes, as well as on farms that are best equipped with machines and trained cadres but have the least amount of common labor available.

IMPLEMENTS FOR CROP MANAGEMENT

The "VIM" cultivator No 1, which has five rows, spaced 70 centimeters apart, is the basic implement for cultivation in the new cotton regions, together with the four-row "Krasniy Aksay" No 8 and the fallow-clearing cultivator TK - 17 of the Orlov plant imeni Medvedev.

Production of "Aksay" No 8 cultivators has been discontinued by the plant, but there is a considerable number of them on the farms.

For working this cultivator, the plant recommended adjustment of operating parts by placing the goosefoot in back and the two cutting blades in front.

Practice has reversed this adjustment, so that now the cutting blades are usually set up on the rear end, and the goosefoot at the front.

With this adjustment the goosefoot collects weeds on its base, makes a deep furrow and does not cover up the rows of plants only because the cutting blades at the back pick up the dislodged earth and throw it backwards, thus smoothing out the relief again. It is better to dispense with the goosefoot during the early cultivations and to set

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three cutting blades on each operating section, so as to avoid covering up the seedlings. With an overlap of 2.5 centimeters, this will give an operating reach of 40 centimeters.

The cutting blades become less clogged with weeds when used alone, and do not rake up the earth even when they do become clogged. For proper use functioning of the cuttingblades, their shape must be maintained unimpaired. Where there are no rhizocarpic weeds, properly sharpened cutting blades irreproachably cut the weeds.

Figure 29 (page 159) The "VIM" Cultivator. Adjustment of the four cutting blades.

The same faults are found in the factory adjustment of the operating parts of the "VIM" cultivator No 1; two cutting blades and two goosefoot blades arranged in checkerboard order. For the early cultivations four cutting blades may be used, bearing in mind that the reach is somewhat smaller than that of the cutting blades of the "Aksay" No 8 cultivator (Figure 30).

Figure 30 (page 160) "Aksay No 8 cultivator. Two blades set for the second transverse cultivation.

Two blades, a right and a left, are set in the middle of a section, in such a way that the rear base of one overlaps with the front of the other, thus giving a working reach of 42 centimeters with an overlap of 3 centimeters.

In view of the packing of the soil between the rows by the tractor wheels, one goosefoot may be left in front, with two cutting blades in back. The goosefoot will pulverize the soil and alleviate

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the harmful effect of soil packing by the tractor. The cultivator does good work on the malignant but not neglected weeds (scutch grass, etc.) only if the cutting edges are frequently sharpened.

These examples of settings of the cutting edges which we have described are suitable for the lengthwise cultivations and for the first transverse cultivation.

We have already pointed out the necessity for reducing the operating reach of a cultivator section for use in the second transverse cultivation.

For this purpose, up to three cutting blades may be left on the "VIM" No 1 cultivator, with an overlap of 3 centimeters, or one cutting blade and one goosefoot, with an overlap of 4 centimeters, while two cutting blades per section may be left on the "Aksay" No 8 cultivator (Figure 30).

The TK-17-E cultivator may be used with goosefoot blades on soils badly infested with scutch grass.

This cultivator undercuts satisfactorily and brings the main mass of the severed rhizomes to the surface. A horse-drawn rake should be used to collect these rhizomes for burning, as such a rake does almost no damage to the young cotton plants when it is run along the rows. The Naurskaya Khlopkosovkhoz has attempted to use this cultivator with spring tongs, but these rake up the earth more than goosefoot blades do and bury more plants also.

None of the cultivators presently in use can work satisfactorily

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to clear cotton fields badly infested with scutch grass. The milling cutter cultivator developed by I. D. Granitskiy, a collaborator of NOVNIKhI, is of considerable interest. (Figure 31).

Two toothed discs are the cutting parts in a section of this cultivator, mounted on vertical spindles and inclined at a certain angle to the plane of the ground.

The discs are geared to rotate with the tractor wheels and make over 400 revolutions per minute.

The sections are placed in a key arrangement. The cultivator excellently undercuts all weeds and leaves them on the surface. including even neglected scutch grass, strongly pulverizes the soil and does not cover any plants at all.

Figure 31 (page 161) The cultivator of Comrade Granitskiy. General view.

The great degree of soil pulverization must be reckoned among the drawbacks of this cultivator.

In working with all cultivators it must be borne in mind that the reach of the weeding operation must correspond in width to that of the planting operation, or cutting of the plants will be inevitable.

MULCH (THERMOGEN) ON THE COTTON FIELDS

In 1929, an article by I. S. Vasserman [I. S. Vasserman. "Cotton and Thermogen." Khlopkovoye Delo No 1, 1929.] attracted the attention of cotton growers. It pointed out the wide use of the so-called thermogen (mulch) on the Hawaiian Islands as a method of weed control and increasing yields in the cultivation of sugarcane and pineapple.

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Thermogen (mulch) is a cheap kind of asphaltized paper, used to cover the spaces between the rows, the entire area of the field or only the rows. There is no need for weeding the areas covered by thermogen, since the weeds cannot penetrate the paper. Besides this, it assures better retention of soil moisture, prevents evaporation and increases the temperature of the surface layer of the soil. The increase of temperature (1.1 - 3.3 degrees under Hawaiian conditions) is explained by the greater heat absorption by the black paper during the daytime and smaller loss of heat by radiation during the night. The idea of using thermogen occurred to Ch. F. Ekart, manager of the Sugar Company at Olaa (Hawaiian Islands).

The United States Department of Agriculture has made a series of experiments with the use of thermogen on various crops, including cotton.

An experiment in 1926 at the Arlington Experimental Field (near Washington), which lies to the north of the main cotton belt, gave the following results:

	Yield in Tsentner per Hectare
With thermogen	7.34
Without thermogen	3.82

On the bases of these experiments some persons concluded that with the aid of thermogen, it would be possible to shift the boundary of commercial cotton growing to the northward. I. S. Vasserman, in particular, especially recommended the wide spread trial of thermogen in the new cotton regions as a radical measure for weed control, improvement of the thermal and water regimens of the soil, preservation of soil structure, etc.

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From 1930 to 1933 there were a large number of experiments in the new regions with the use of thermogen on the cotton fields.

The Taman' Station gives the following lint yield data in tsentner per hectare, for use of mulch on the spaces between the rows:

	1930 warm and dry	1931 warm moist	1932 moderately warm and moist	1933 cool and moist	Four-year Average
Without mulch	4.8	14.7	15.2	7.8	10.6
With mulch	5.8	15.9	13.1	6.7	10.4

In 1930, when precipitation was lowest, mulching had its greatest relative effect.

In 1931, which was warm and rainy, increased yield is also noted on mulched plants. During the flowering period of cotton, in 1931, soil temperature was measured at a depth of 15 centimeters for 10 days, at 0700, 1300 and 2100 hours.

	Soil Temperature in degrees at 15 Centimeter depth.
Without mulch	25.8
With mulch	25.5

In the same year, soil moisture was somewhat higher on the mulched plots:

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Horizon in Centimeters	Without Mulch		With Mulch	
	4 August	20 September	4 August	20 September
0 - 10	12.5	11.8	14.2	12.6
10 - 20	13.4	12.5	15.4	12.7
0 - 50	14.6	12.3	16.2	12.5

While mulch protects against evaporation, it apparently does not prevent the summer rains from penetrating into the soil. When mulch is laid between the rows, the rain water can roll down into the rows and be absorbed into the soil.

This circumstance was also the reason for the effectiveness of mulch in 1931.

When rainfall was abundant, mulch considerably reduced the yield, both in 1932 and 1933, in spite of the marked contrast between these years in respect to heat.

In 1933, in contrast to previous years, there is a sharp difference in the times of development of cotton, which is reflected in the retardation of maturation on the mulched plots.

In Crimea (Novopokrovka village, Feodosiyskiy Rayon) the following lint yield data in tsentner per hectare, were obtained in 1931 and 1932;

	1931	1932
Without Mulch	6.0	4.3
With Mulch	7.7	4.4

In 1931, under drought conditions in Crimea, mulching thus increased the lint yield.

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At Kherson, in 1933, which was a humid year and one exceptionally deficient in heat, mulching gave negative results (control, 1.13 tsentner of lint per hectare; mulch, 1.0 tsentner.) Detailed observation of soil temperature and soil moisture established a slight reduction of soil temperature beneath the mulch at the 10 centimeter level.

At the same time a considerable increase in soil moisture during the dryest period (August 8) was noted.

/For table see next page/

In 1931 and 1932 mulching also failed to give positive results at the same station.

It must be added to the above results that laying mulch between the rows was no guarantee of protection against weeds for the cotton plant, since weeds strongly developed in the rows.

Weeding in the rows caused damage by the workers to the mulching. Mulching in the rows was attempted, but the use of narrower mulching belts led to its reduced effectiveness.

Continuous covering of the entire plots with mulch, followed by hill check of cotton with specially made apertures in the mulch, hindered access of summer rains to the soil and reduced yield.

Kherson, 1931	Lint Yield in Tsenter per hectare
Control	16.3
Mulch between the rows	15.2
Continuous mulch covering	14.0

It must be pointed out that with the prevalence of strong winds over most of the new cotton regions the usual methods of applying mulch

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Horizon, in Centimeters	Control			Mulch		
	August 4	September 8	October 27	August 4	September 8	October 27
0 - 10	7.6	15.8	16.8	7.8	15.6	17.0
10 - 20	8.6	17.0	18.4	10.4	15.1	17.7
0 - 100	11.5	10.9	11.9	12.4	10.3	11.9

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(forked pegs, covering the edges with earth, etc.) have not proved practical. The mulch on the entire field was frequently torn and carried away by the wind.

In spite of the series of cases in which positive effect of mulching was noted, most of them in arid years, the conclusion must nevertheless be drawn that this method (in the present state of the art) is unsuitable for the new cotton regions, the more so in view of the fact that a number of cases have also been noted (in humid years) in which mulching has adversely affected yield. /I. S. Varuntsyan, "First Experiments with the Use of Thermogen". Trudy Zaknikhi Issue 17, 1932./ I.S. Varuntsyan has noted no positive action of thermogen at Gandzhe, with proper irrigation. Further than that, contrary to the findings of Vasserman, he noted deterioration in the thermal regimen of the soil under thermogen, with 1 - 2 degrees temperature reductions. Without irrigation a yield increase of 21.5 percent was obtained.

This circumstance permitted I. S. Varuntsyan to note the prospects of thermogen for use in areas of unirrigated cotton growing. It is possible that in the unirrigated cotton areas of Central Asia, where yield depends almost entirely on the spring stocks of soil moisture, the application of thermogen may have significance.

In the new cotton regions, on the contrary, there were years (1932, 1933) when, with increased soil moisture and low heat levels, thermogen reduced the yield. "The accumulation of nitrates and of carbonic acid in the soil air was considerably increased under mulch" /V. V. Yakovleva. "The Biochemical Processes in the Soil in Connection with Mulching." Khimizatsiya Sotsialisticheskogo Zemledeliya, No 6, 1933./.

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The Gorskaya Zonal Station reached the same conclusion. The conclusion with respect to nitrates cannot be convincing, inasmuch as the yield of corn was sharply reduced in mulched plots, and the observed increase in nitrates apparently resulted from lessened consumption. There have been attempts to create a dead cover of straw (witha 5 - 7 centimeter layer) over the soil, for purposes of weed control and moisture conservation. Experiments in Kherson and Skadovsk showed that the weeds easily pierce through the straw. Yield data was as follows:

	Kherson, 1931	Skadovsk, 1932
Control	16.3	9.1
Mulch between the rows	15.2	9.8
Straw Cover	12.8	7.2

In both cases, yield of cotton plants was sharply reduced with a straw cover.

A straw cover does even greater harm to the spring crop following cotton. In 1933, the yield of barley at Kherson was 17.2 tsentner per hectare when sown in the usual way, but when sown after plowing under, in the spring, of the straw cover on the previous year's cotton crop, it fell to 9.8 tsentner. The cause of this was obviously the strong denitrification of the soil in connection with the vigorous decomposition of the straw in the humid year 1933.

THE HILLING OF COTTON

In experiments by the Ak-Kavak Experimental Irrigation Station, no advantages were noted for either deep hilling or deep cultivation of the cotton fields. "Deep hilling gives negligible yield increases overshallow hilling and is not economically justified in any case." (A. F. Makarov). [A. F. Makarov. "Irrigation and Inter-Row Cultivation

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of Cotton" Za Khlopkovuyu Nezavisimost. No 4, 1931.7

The different plowing depths of cultivators, set at 7 - 8 centimeters and at 12 - 15 centimeters, gave the same lint yields there.

Terraced cultivation of cotton cannot be practiced in the new cotton regions, which are subject to drought, as it is in many of the cotton states of North America, which have a superfluity of rainfall.

In the new cotton regions, the first cultivations should be as shallow as possible so as to avoid covering the young cotton seedlings with earth.

Only the third and fourth cultivations may be deepened to 5 - 6 centimeters.

In the chernozem cotton areas of the Kuban' (Krasnodarskiy Rayon and part of Slavyanskiy Rayon) where rainfall is exceptionally good, there have been successful experiments in cotton growing by the hilling method. In these cases, a certain drying out of the upper horizons was attained, thus increasing the warming through of the soil; cotton plants "fattened" less on the hilled fields and began to open their bolls earlier.

On the chestnut soils and chestnut chernozems of most of the remaining other new cotton regions, late hilling is sometimes recommended to accelerate the boll-opening.

No definite positive results were noted in experiments at Kherson and Taman'.

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TOPPING OF THE COTTON PLANT

The removal of the tip of the main stalk (topping) of the cotton plant "may be recommended as a measure for increasing the lint yield in conditions and areas where development is particularly strong and deep. (A. F. Makarov) [A. F. Makarov. "The Topping of Cotton." Khlopkovoye Delo No 10 - 11, 1930]. Timely topping under such circumstances may result in good fruiting on the lower fruiting branches, which on well developed plants often fail to yield developed bolls because of the enfeebled access of light. If topping is too early (before flowering) it often does harm, since it causes the formation of numerous additional monopodial branches, which are tardy in development and reduce the yield.

Once the plant is completely formed, later topping is useless.

It is difficult to determine the optimum time for topping in each individual case, and no work has been done on the subject in the new cotton regions.

Separate experiments on topping in the new regions yielded no results. Topping proved ineffecting in 1928 at Odessa and in 1931 at Kherson.

The Kuban' Agricultural Experiment Station in 1928 noted an increased percentage of pre-frost yield under the influence of topping.

Since spacing is relatively close in the new cotton areas, and early varieties [redacted] not inclined to monopodial branching or lush growth are planted, it is rather doubtful whether topping would be expedient.

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KILLING THE COTTON PLANT

In the new cotton regions, cold rainy weather not infrequently sets in even before the first autumn frost, causing considerable delay in boll-opening and creating the conditions for the spread of fungus and bacterial diseases of the bolls and lint.

It has been noticed that under these circumstances even a relatively early frost that kills the plants (the leaves and locks of the bolls) is often a desirable phenomenon, since it causes the bolls to dry thoroughly and accelerates opening.

All possible proposals have been made for the complete or partial killing of the plants by spraying or dusting with various herbicides (chemical poisons), by undercutting excision of the roots, by ringing the "bark" of the cotton plant, and finally, the simple premature harvesting of the green unopened bolls by means of "snipping", sledding or cutting off the whole plant.

All these operations are desirable methods only in cases where it may be considered more or less probable that the further course of the autumn will be cold and that the growth in boll-weight has been, for all practical purposes, terminated.

It is, however, extremely desirable that the operation of killing should be immediately followed by a period of warm, dry weather, however short, to cause the rapid opening of the bolls and make it possible to pick them at the same time.

In 1931, at Kherson, cotton plants were torn up at various stages, prematurely. The bolls opened by natural drying out in the open air.

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Killing of some plants with sodium arsenite at the beginning of maturation, when 50 percent of the bolls had opened, was also tried.

The following yields were obtained in the various pickings:

Kherson, 1931	Yield to October 10	Yield to November 10	Linters	Total
Control	3.8	4.2	3.5	11.5
Tearing up plants on August 24, 30 days after onset of flowering	2.9	1.6	0.7	5.2
Same on September 9, 40 days after onset of flowering	6.1	5.2	0.5	11.8
Spraying at beginning of maturation, on September 16	5.3	4.5	2.1	11.9

Thus, under the conditions at Kherson in 1931, tearing up the plants on September 3 or killing them on September 16, during the beginning of maturation, did not reduce the total yield and favored the rapid opening of the bolls. Earlier tearing up of the plants sharply reduced the yield.

In 1932, at Kherson, spraying with sodium arsenite at the beginning of maturation (September 26) after the first picking, reduced the total yield, as the weather remained warm and dry, assuring complete maturation of all the late bolls in the check plot, as will be seen from the following data:

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Kherson, 1932 /	Lint Yield in Tsentner per Hectare at Picking of: 6 October	25 October	26 November	Total
Control	5.5	4.2	1.9	11.6
Excision of the laterals	4.4	3.3	1.6	9.3
Spraying at beginning of maturation on 26 September	7.5	--	1.5	9.0
Same, on 15 October, after first picking	4.6	5.3	0.8	10.7

In 1933, experiments with killing the plants by means of various herbicides, performed at Taman' and Kherson, accelerated the cracking of the bolls. In consequence of high atmospheric humidity and frequent rains, complete opening of the bolls was not attained.

At Kherson, for instance, the first light frost, on October 8, killed only the leaves of the cotton plant. On October 14 the killing operation was performed on the plants, by spraying with sodium arsenite. On the fourth day after, 14 percent of the bolls on the control had opened, and 76 to 79 percent of the bolls on the sprayed plants.

However, under the conditions of the autumn of 1933, when rain and fog was frequent, the cracked bolls could not dry through, and rain entered them, provoking strong rotting of the lint and causing great yield loss. In consequence the total yield was reduced on the treated plots and quality was inferior.

Kherson, 1933	Percent of Opened Bolls on October 18	Total Lint Yield
Control	14	1.4
Sprayed with 1 percent solution of sodium arsenite, 14 October	77	0.6
Same, 2 percent solution	76	0.6
Same, 3 percent solution	79	0.7

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Under the conditions in the Ukraine, the only measure to save the 1933 crop from fungus and bacterial diseases caused by the mass rotting of the bolls was timely picking, followed by immediate drying of the bolls in a drying apparatus.

Some of the facts we have presented indicate the impossibility of utilizing the measures described for accelerating boll-opening in advance of the more or less precise determination of the conditions for their positive effect. Apparently the practical application of chemical and other methods of plant-killing will be intimately connected with the success of meteorology in weather forecasting.

Sodium arsenite in 1 percent solution, and sulphuric acid proved to give the best effects among the herbicides tested. Sulphuric acid damages the fiber by drops of the strong acid entering between the locks of the bolls, and thus cannot be recommended.

Ferrous sulphate, or copperas, gave the worst results. Calcium arsenite of USSR production can also be used for plant-killing. Obviously, even if the problem as to the practical application of plant-killing to cotton growing should be decided affirmatively, it would not be necessary to resort frequently to this method - only in relatively infrequent seasons and not in all areas.

It would hardly be expedient for farms to have a special inventory for this purpose; supplies of poison, etc.

From this point of view the 1933 experiments of NOVNIKhI, condicted jointly with the Institute of Agricultural Aviation, at the Naurskaya and Stoderevsk Khlopkosovkhozes in North Caucasus are of particular interest. They established the entire practicability of

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applying chemicals by airplane for plant-killing purposes.

Dusting of calcium arsenite by airplane at the rate of 6 to 10 kilograms produced wilting of the leaves within two to three days. As a result of the work a considerable acceleration in boll-opening was observed, and the yield at the first picking was almost doubled, with a slight loss in the total yield. The most successful dusting was performed on the Naurskaya Sovkhoz on 20 September in the early morning, with abundant dew and light wind.

The airplane, flying 3 to 3.5 meters above the ground, emitted a dust wave 20 meters wide.

For purposes of plant-killing the airplane will probably be the most suitable for use as an agricultural machine.

In view of their exceptional importance for the new cotton regions, the questions of vernalization of the cotton plant demand special consideration in another paper.

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